METALLURGIA

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# New Siemens Melting Plant

*Rapid development in the various branches of engineering has only been possible as a result of the successful application of valuable research work on steel manufacture, and the new Siemens melting department recently completed at the Vickers Works of the English Steel Corporation has an important significance in view of the recent reorganisation of the metallurgical and research department at their works. It will place this Corporation in a better position to maintain that scientific understanding and control of the various compositions of steel which research and service conditions have shown to be necessary to meet demands.*

*General arrangement of the furnaces on the charging stage.*

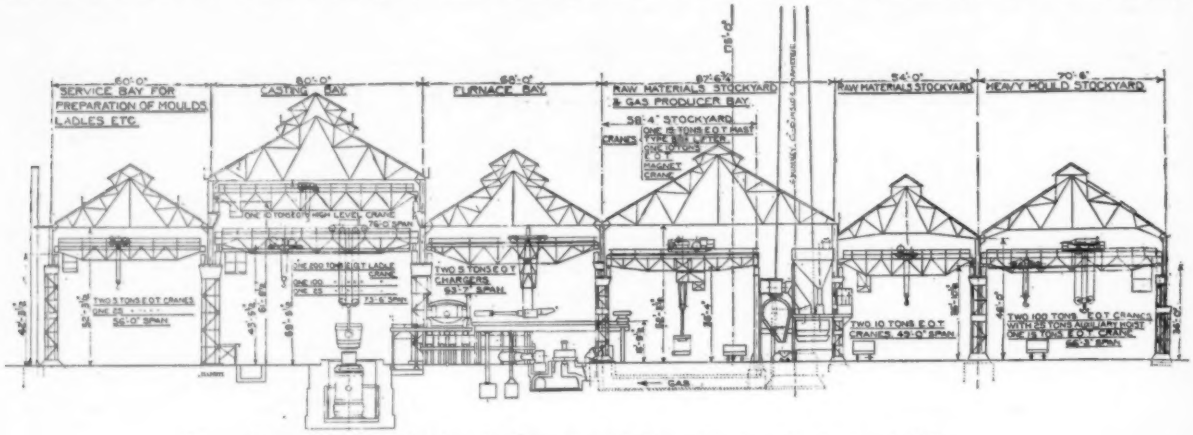
RECENT developments have shown how much civilisation depends upon the scientific understanding, handling, and control of the various qualities of steel. In every branch of engineering there have been increasing demands for carbon and alloy steels of the highest quality possessing remarkable physical properties. To appreciate the dependence placed upon steel, it is only necessary to mention the super power stations, the wide range of chemical plants and oil-cracking plants, the remarkable development of aircraft in regard to speed and endurance, and the progress in motor-car and speed-boat engineering. In all the branches of electrical, general, and marine engineering, however, there is a continual call for steels that are not only strong and hard, but are, at the same time, tough, ductile, resistant to shock and impact, and possessed of high fatigue values under varying conditions of service.

The provision of these steels demands persistent research in order to approach ideal conditions as closely as possible within the limitations set by economic and other practical considerations. This naturally involves a continual correlation between cause and effect—that is, between physical structure and chemical composition, on the one hand, and function on the other, so that the ideal structure and composition may be selected for a given function in the minimum of time. When steels are developed for a particular purpose they are subject to very rigid specification requirements which necessitate a very fine control of permissible limits of composition. It will be realised, therefore, that to make such steels in large quantities the most modern furnaces must be used and strict scientific control must be maintained; it also involves skill and experience in handling the furnaces.

In an earlier issue* a description was given of the extended metallurgical and research department of the English Steel Corporation as part of a comprehensive and complete scheme of reorganisation undertaken when the steel interests of Vickers, Ltd., Sir W. G. Armstrong Whitworth, and Cammell Laird were taken over by this Corporation in 1929. A further substantial contribution to this scheme has just been completed by the building of a Siemens melting department embodying the very latest practice. In addition, the various machine shops have been entirely rearranged and centralised, and the forge department is at present being rebuilt and re-equipped with the object of centralising in one department the principal forge plants of the various branches.

*Metallurgia, Vol. 5, No. 27.

This Siemens melting department has been entirely reconstructed and modernised. The building comprises six bays, which include the service bay for the preparation of moulds, ladles, etc ; the casting bay ; the furnace bay ; the raw-material loading bay ; the stockyard bay for raw material ; and the heavy ingot mould stockyard bay. The area covered by these buildings is 17,500 sq. yds., and their cubical contents 387,694 cub. yds. The buildings inclusive of the amount occupied by the furnaces themselves, has a total area ot 33,600 sq. ft. or 8,400 sq. ft. per furnace, the front, or tapping side, being 13 in. lower than the charging side. The width on the tapping side is 11 ft. clear of the furnace binders. The stage is designed for a load of 3 cwt. per sq. ft., the floor plates being $\frac{5}{8}$ in. thick, and is kept entirely clear of the furnaces so that each furnace may expand independently, and the stage plates


SERVICE BAY FOR PREPARATION OF MOULDS LADLES ETC
CASTING BAY
FURNACE BAY
RAW MATERIALS STOCKYARD & GAS PRODUCER BAY
RAW MATERIALS STOCKYARD
HEAVY MOULD STOCKYARD
TWO 10 TONS E.O.T. CRANES 45'-0" SPAN
GAS

*An end elevation showing the disposition of the various bays in the new building.*

are of steel, covered with Robertson's asbestos-protected metal corrugated sheets, a considerable portion of the roofs being glazed. The whole of the steelwork was supplied and erected by Sir Wm. Arrol and Co., Ltd., of Glasgow.

Three 60-ton acid open-hearth furnaces are installed in the furnace bay, and space is available for a fourth similar furnace ; each has its separate brick chimney stack. They are of the most modern type for dealing with the higher grades of carbon and alloy steels, and were designed and built by Messrs. G. P. Wincott, Ltd., of Sheffield. The main particulars of each furnace are as follows :—Air chequer chambers, each side, 21 ft. × 11 ft. 4 in. × 18 ft. 6½ in high ; gas chequer chambers, each side, 21 ft. × 7 ft. 7 in. × 18 ft. 6½ in. high ; air ports, one at each end, 8 ft. wide × 1 ft. 4½ in. high ; gas ports, one at each end, 2 ft. 3 in. wide × 1 ft. 6 in. high ; air reversing valve, " Blaw Knox " water cooled, electrically operated ; gas reversing valve, " Dyblie " 36 in. water-sealed, electrically operated ; diameter of chimney inside lining, 6 ft. ; height of chimney, 185 ft. ; furnace cross section, 12 ft. × 7 ft. 9 in. ; size of bath, 28 ft. × 12 ft. ; space between blocks, 31 ft.

The longitudinal span of the columns in front of the furnaces is 93 ft. 6 in., which enables the whole of the furnace foundations to be kept entirely clear of the foundations of the building. The furnace stage is 89 ft. wide and, are divided at each furnace to allow them to expand or contract at will.

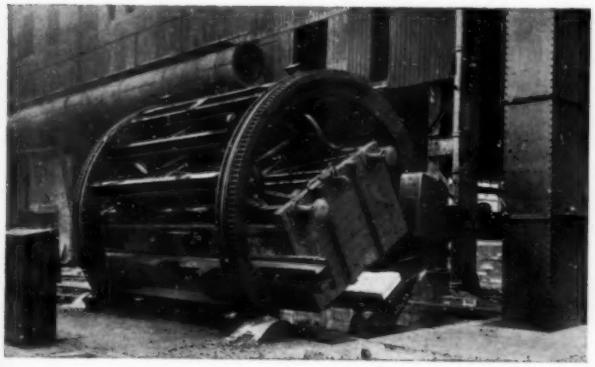
*A general view of the stockyard bay.*

The chequer chambers are entirely clear of the furnace bath so as to facilitate the removal of slag and of other material in the event of a break-out. Each furnace has three charging doors and two fettling doors on the charging side, and two fettling doors on the tapping side, the charging doors being operated by Blaw Knox electric door-lifting mechanism. The gas and air valves are automatically reversed, after a prior warning by a powerful Klaxon horn, by means of a " Leeds and Northrup " automatic reversing equipment, which can, however, be switched over to hand control when desired. Indicators, placed away from the furnaces at the back of the stage, show the direction of the incoming gas and air, the pressure in the gas mains, the ratio of gas to air, the temperatures in the regenerator chambers, the chimney draught, the temperature of the waste gases, and the amount of $CO_2$ in the products of combustion, all of which are recorded on charts. The furnaces are, therefore, under complete control, and complete records of all " heats " are available.

At the back of the stage is a continuous gantry—part of the stage itself—over which the cranes in the loading-up bay can run, and on this gantry the standard 2-tons charging boxes are placed in a loaded condition. The overhead chargers in the furnace bay take these boxes direct from the gantry and empty them direct into the furnaces. The charging boxes are filled with the necessary raw material in the loading-up bay, in which are placed two 15-tons special platform weighing machines. These are situated at about one-third of the length of the bay from either end and are each capable of weighing three loaded boxes at the same time. At the south end of the casting bay, on the side away from the furnaces, is a casting platform, below and in front of which are placed the mould bottoms, upon which are set the moulds for casting. The furnaces are tapped direct into 70- or 80-ton ladles, which are carried directly over the moulds for casting purposes. Various types of moulds are used, both top and bottom pouring being adopted, and ingots can be cast of all weights up to a maximum of 250 tons. In this bay also are three large casting pits for accommodating the larger ingot moulds. The internal sizes of the largest of these are 24 ft. × 20 ft. 10 in. × 20 ft. 6 in. deep, the other two being slightly smaller. Two coke-fired stoves, supplied by Priest Furnaces, Ltd., of Middlesbrough, form part of the installation in the casting bay ; these are used for drying the linings of ladles, mould heads, etc.

The gas plant comprises two "Morgan" gas machines, each 11 ft. diameter inside brick lining, 12 ft. 4 in. diameter inside stationary shell, with revolving bottom, 13 ft. diameter, fitted with water jacket and mounted on three rollers having "Skefko" bearings, each machine being capable of gasifying 60/70 cwt. of coal per hour. The gas machines are fed from overhead coal bunkers, each of which has a capacity of about 60 tons of coal. Coal is delivered in standard railway wagons to a Babcock and Wilcox automatic wagon tippler situated outside the building at the northern end of the loading-up bay. This tippler empties the contents of the wagon bodily into a large underground coal bunker, from whence an elevator raises the coal to an overhead conveyer which carries it to the coal bunkers situated over each gas machine. The ashes are automatically ejected into side-tipping bogies which, in turn, place them into an underground ash bunker, from which an elevator carries them to an overhead storage bunker, from which they gravitate through a controlled opening into railway wagons for disposal. The whole of the coal and ash elevating and conveying plant is electrically

*Tapping one of the 60-ton acid open-hearth furnaces.*



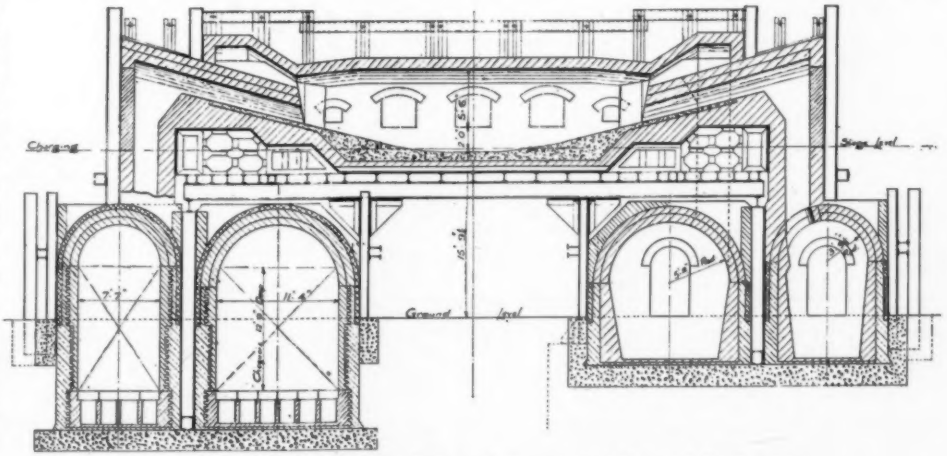
*Babcock and Wilcox automatic wagon tippler.*

operated by push-button control from three different stations—viz., at the producer platform, at the ground bunker, and at the motors,—the current being automatically switched off when either or both of the overhead coal bunkers are full, as desired. The gas from the producers is carried into a common gas-box and dust-catcher, and separate downtakes convey it into underground flues to each of the furnaces. The producers are fitted with "Arca" gas-pressure regulator, gas-temperature recorders, and recording and indicating thermometers for blast temperature, and are electrically operated.

A motor-driven manganese crusher, with a bin for the raw material, is installed in this bay, and at the northern end of the same bay is a large sand bunker, adjacent to which is a motor-driven sand-drying machine. At the southern end of the furnace bay is situated a block of offices, etc., a brick building consisting on the ground floor of an auxiliary sub-station with transformers for the distribution of current to the plant generally. On the upper floor is a fully equipped laboratory for the analysis of samples. The staff offices, lavatories, cloakrooms, etc., are also on this floor, which is at the level of and entered from the furnace stage, the whole arrangement being designed to render the control and management of the furnaces and plant as easy as possible.

The crane equipment comprises 16 electric overhead travelling cranes of capacities varying from 5 to 200 tons. Thus, in the mould preparation bay there are two 5-ton 'Craven" cranes and one 25-ton "Wellman" general service crane. In the casting bay are four cranes, comprising one 200-ton "Arrol" ladle crane with a 50-ton auxiliary hoist; one 100-ton "Arrol" ladle crane with a 25-ton auxiliary hoist; one 25-ton "Wellman" crane on the low-level track and one 10-ton "Arrol" general service crane on the high-level track. In the furnace bay are two 5-ton "Wellman" slewing electric overhead furnace chargers, each equipped with a 10-ton auxiliary crab. Two "Wellman" cranes are installed in the loading bay, one being a 15-ton combined box lifter and magnet crane, and the other a 10-ton general service magnet crane. In the raw material stockyard bay a 10-ton "Arrol" and a 10-ton "Wellman" general service cranes form the lifting and transporting equipment; while in the heavy-ingot mould stockyard bay are two 100-ton "Arrol" ladle cranes, each with a 25-ton auxiliary hoist, and a 15-ton "Arrol" general service crane.

With this new Siemens melting plant, and the experience gained from over a century by the firms incorporated, the English Steel Corporation is placed in a unique position




*A longitudinal section showing the general arrangement of one of the furnaces.*

for the manufacture of all the special steels required, not only by its customers, but also by the various departments in the Vickers Works, where it manufactures large hollow forged steel vessels, weighing up to 100 tons, for use in chemical and oil engineering processes and power plants

under conditions of high temperature and pressure; forgings, such as marine crankshafts, propeller shafts, high-speed electrical rotors, locomotive crankaxles, etc.; drop forgings for automobile aircraft and general engineering, such as the crankshafts and other important parts supplied by this firm for all British high-speed, record-breaking machines, tyres, axles, and springs for railway and tramway rolling-stock, springs and frames for road vehicles.

To meet the rapidly expanding fields of activity, in which steel plays so important a part, much concentrated effort and scientific knowledge are required, and collaboration between the melting plant and the metallurgical and research departments characteristic of these works will facilitate progress and materially assist in the manufacture of the highest grades of carbon and alloy steels possessing reliable physical properties.

*Morgan gas machines.*

A large party of members of the Iron and Steel Institute from the Sheffield Conference visited the Vickers Works, and this new furnace plant was viewed with ill-concealed envy by many of the visitors, and the opinion was expressed that there was probably nothing finer in the world for the manufacture of high-grade steels on an economical and practical basis.

## Definitions and Symbols for Welding and Cutting.

The rapid development of the art of welding, and especially of fusion welding, has introduced a technique and vocabulary which is all its own. The preparation of a standard list of terms applicable to the art, defining what each means, is a matter of prime importance. "The Standard Nomenclature, Definitions, and Symbols for Welding and Cutting," which has just been issued by the British Standards Institution (B.S.S. No. 499), has been prepared to meet this need, and will be found to contain much that is of importance in regard to the application of welding.

Two distinct and definite objects have been kept in view in preparing this standard. One to establish agreement as to the exact meaning to be attached to terms that have become associated with welding practice, and the other to draw up a standard system by means of which the form and details of welded joints can be readily indicated on engineering drawings.

The desirability of something being done with regard to both of these objects will be readily apparent. In the development of any art or process of manufacture in industry it is necessary for new terms to be evolved, but unless these are standardised when the industry is young, they frequently become misused and misapplied, and considerable confusion and ambiguity is occasioned. This state of affairs is not altogether absent with regard to welding. To take but an isolated instance, there is a diversity of practice in the method of specifying the size of a fillet weld. The strength of a fillet weld, assuming it to be a perfect right-angled triangle in shape, is dependent on the length of the perpendicular line from the right angle to the hypotenuse—*i.e.*, the "throat dimension." This has resulted in a tendency in some quarters for the size of the fillet to be defined on drawings by this dimension.

On the other hand, it is easier in the workshop to ascertain the size of a fillet weld by measuring the length of the "legs"—*i.e.*, the length of the weld which is in actual fusion with the edges of the plate,—and this method of indicating the size of the fillet weld has also been largely used. It is this latter method which has been adopted as standard.

In the standard which has now been issued, welding terms have, for ease of reference, been grouped under five main sections, as follows:—

I. Definitions of general terms applicable to all forms of welding, and also including cutting terms.
II. Definitions of methods and joints relating to forge welding.
III. Definitions of methods, terms, and joints relating to pressure welding.
IV. Definitions of methods, terms, and joints relating to fusion welding.
V. Definitions of terms relating to welding and cutting equipment and supplies.

A complete alphabetical index has been included so that the definition number of any term can be easily found, and the term readily traced. Where desirable, in order to prevent the possibility of misunderstanding, illustrations and diagrams have been inserted.

The achievement of the second object—namely, that of standardising a system for the indication of welds on engineering drawings, was one which presented no little difficulty, and it occasioned much thought and careful consideration on the part of the Committee.

Certain of the national standardising bodies have adopted diagrammatic symbols to define a weld. This system, however, has the great drawback that it is extremely limited in the number of joints to which it can be applied, and, further, it does not allow a means for indicating the many variations in the details of a weld that may be met with in any one of the forms of joint which are in general use.

It was felt that for a standard scheme to be really successful it was essential that it should possess the following three main characteristics: (*a*) It should be simple, easy to adopt, and readily followed; (*b*) it should be comprehensive, and cover as wide a range of welded joints as possible; (*c*) it should be adaptable, so that it would be possible to indicate the variations that may occur in the details of joints of the same general form.

The Committee felt that these essentials could not possibly be met by means of diagrammatic symbols, and they have accordingly put forward a system in which a capital letter is used to indicate the general form of joint, such as "B" or "T," for a butt-joint and tee-joint respectively, and a combination of numbers and suffix letters is appended to indicate the particular form of weld, and there is also a statement of the dimensions to be given.

Details of the working of the scheme are given in full, together with an explanatory chart; an illustration of each form of fusion welded joint is included, and a weld symbol given to it.

Whilst it might appear at first sight that a scheme of this character would necessitate memorising a lengthy list of symbols, the Committee wish to emphasise that in normal circumstances the forms of joints employed in any one engineering establishment are small in number. They recommend, therefore, that the weld symbols for the few joints employed should be displayed prominently in the drawing office and the engineering shop concerned, so that their adoption will not involve any difficulty.

From the brief outline given above, it will be seen that the new standard should be very useful in the rapidly widening sphere in which welding is being applied in the engineering industry. It is of particular importance that those entering the industry should, from the beginning of their training, use the definitions, terms, and symbols now standardised.

As far as the symbols for indicating welds are concerned, the standard will become an essential adjunct to B.S.S. No. 308, Engineering Drawing Office Practice, in which the usual symbols used on engineering drawings are standardised.

Copies of the new publication (British Standard No. 499-1933) can be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W. 1, price 2s. 3d. post free.

# Institute of Metals Celebrate Silver Jubilee

More than usual interest was centred in this meeting and a large attendance of members were present. The gathering of the original members assisted in making the occasion a memorable one.

FOUNDED in Birmingham 25 years ago it is appropriate that the anniversary celebrations of the Institute of Metals should be held in that city. Thus the autumn meeting, held on September 18-21, under the presidency of Sir Henry Fowler, was of an outstanding character. The arrangements for the meeting were well worthy of the historic occasion. They included on the technical side an inaugural lecture on "Twenty-five Years' Progress in Metallurgical Plant," by Mr. W. R. Barclay, O.B.E. (vice-president), a series of 14 papers dealing with various phases of metallurgical work, and visits to a number of works of engineering and metallurgical interest. The social side of the Conference had not been overlooked, and the proceedings included municipal and university receptions and a special luncheon, as well as visits to places of interest in the Midlands.

A specially interesting feature of the Conference was the reproduction of the first office of the Institute of Metals. This was located in the Metallurgical Department of Birmingham University, and was set up by the Institute's first and only secretary, Mr. G. Shaw Scott, M.Sc., who, with the president and the chairman of the Executive Committee, received the remaining original members of the Institute in the reconstituted office. Here visitors had an opportunity of inspecting the earliest records of the Institute—including the original membership applications, and the first letters to be typed on a machine, which was shown to be still in working order—and photographs taken during the inaugural meeting in 1908. During Mr. Shaw Scott's 25-year period of office as secretary and editor it is worthy of note that the membership of the Institute has increased from 200 to 2,200. Whereas originally the membership was confined almost entirely to Great Britain it now covers the whole world.

Two morning sessions were allocated to technical papers, and in view of the limited time some were not discussed at the first meeting. Dr. W. Rosenhain briefly reviewed some of the most important steps in metallurgical progress during the 25 years of the existence of the Institute of Metals. The matters touched on were those which have been of particular interest to the author, and have been in some degree associated with the Institute of Metals. They included the following: age-hardening and the development of new alloys capable of improvement by heat-treatment; Y-alloy and other casting alloys capable of benefiting by heat-treatment; the "modification" of alloys; "aluminium-bronzes" and brasses, the Durville and other special methods of casting ingots or billets; metals of very high purity; alloys for cutting tools—Stellite and sintered tungsten carbide; removal of gases from molten metals and alloys; the mechanical behaviour of metals—slip, fatigue, plastic deformation; the study of metals by X-rays and by electron diffraction; recent vindication of Beilby's hypothesis of "amorphous" metal; corrosion and the differential aeration theory; the protective surface film and its isolation; corrosion-fatigue.

A study has been made of the effect of quenching and tempering on the properties of a number of copper alloys containing nickel and aluminium by Messrs. H. W. Brownsdon, Maurice Cook, and H. J. Miller, and it has been found that when nickel together with aluminium are present in certain quantities and ratios, the hardness and other mechanical properties of the alloys are very considerably modified by the thermal treatment to which they are submitted. The alloys are softened by quenching from relatively high temperatures, and the quenched alloys, both in the soft and cold-worked conditions, harden considerably when reheated or tempered to an intermediate temperature somewhat below the annealing temperature. For a few typical alloys the changes in hardness and mechanical properties that can be brought about by suitable heat-treatment were given in some detail in this paper.

The properties of nickel-copper-aluminium alloys with nickel contents from 10% to 45% and aluminium contents up to 4% have been investigated, and the results were discussed in a paper by Messrs. D. G. Jones, L. B. Pfeil, and W. T. Griffiths. In this investigation the relationships between composition and capacity for hardening by heat-treatment have been studied by means of hardness tests on the heat-treated specimens. A study has also been made of the most suitable heat-treatments to produce the soft condition, and the stability at elevated temperatures of a selection of the alloys in the precipitation-hardened condition. Finally, the mechanical properties have been determined of a group of alloys selected and prepared in accordance with the results of the preliminary experiments. In certain cases the properties of the 20% nickel alloys were studied in greater detail than those at other nickel levels, but sufficient work has been carried out on alloys containing 10, 30, and 45% nickel to enable the properties of alloys at these levels and over a range of aluminium contents, and in various conditions of heat-treatment, to be deduced.

A series of tests was made in the laboratory of the British Non-ferrous Metals Research Association to determine the comparative rates of wear of plates and other metal specimens under conditions of polishing as distinct from abrasion. These were discussed in a paper by Mr. O. F. Hudson. The apparatus used was described, and the results obtained with the following materials were given, using magnesia on wet parchment as the polishing medium: pure platinum, pure palladium, platinum plating on brass, palladium plating ("soft," "hard," and burnished) on brass, nickel plating ("soft" and "hard") on brass, silver plating, and brass (60 : 40). Considered as loss of thickness, the rate of wear of the palladium-plated specimens was found to be greater than that of the platinum-plated specimens, but considered as loss of weight, the wear of the palladium coatings was slightly less than that of the platinum coatings; whilst the precious metal coatings generally were more resistant than the same metals in massive form. Of the three types of palladium-plating, that in the "soft" condition showed the greatest wear, but the differences were not great; there was little difference in the rates of wear of the two kinds of nickel-plating. No definite or consistent relationship between hardness and rate of wear in polishing was revealed in these tests.

At the second meeting Mr. N. P. Allen described further observations on the distribution of porosity in aluminium and copper ingots, and gave some notes on inverse segregation. In this investigation three copper ingots and four aluminium alloy ingots cast in a specially tapered mould have been examined. In all cases, the author stated, the distribution of porosity followed the

probable form of the isotherms in the cooling mass, and was much influenced by the mould taper. The type of micro-structure also had an influence on the distribution of porosity, the nature of which was discussed. The inverse segregation of two aluminium-copper alloy ingots has been found to be closely related to their porosity.

A further contribution to the study of magnesium alloy protection by selenium and other coating processes was given in a paper by Messrs. G. D. Bengough and L. Whitby. It has been found that small losses of weight of Elektron alloy AZM (sheet) resulting from corrosion by immersion in, or spraying with, sea-water are associated with serious losses of elongation. Visual inspection did not suggest the extent of the damage, which occurred even when the alloy was protected by chemical coatings and paint.

Further examples of green patina on copper have been sought that would illustrate the characteristic green coating under conditions as remote as possible from the town, yet not too near the sea, have been studied by Dr. W. H. J. Vernon. Analyses of the products of two have yielded interesting results which were recorded in this paper. The patina from a copper structure in mid-Wales contained 20.75% basic copper chloride, as compared with 8.15% in the patina from a copper spire at Dundalk, on the east coast of Ireland (approximate ratio 2.5 : 1) ; this result is attributed to the influence of prevailing winds. Basic copper sulphate constituted the bulk of the deposit in each case, relationship of formula with period of exposure confirming the conclusions of previous work.

A description of experiments, and a discussion of the results on a series of wires of silver-free high-conductivity copper, drawn to the same diameter, but to widely varying degrees of hardness, were given in a paper by Messrs. W. E. Alkins and W. Cartwright. In the experiments silver-free h.c. copper of good quality (99.95%) copper was drawn into nominal No. 12 S.W.G. (0.104 in.) wire, intermediate annealing being introduced in such a way as to furnish eleven coils of wire varying in breaking load from 399 lb. 544 lb., and with reductions of area after annealing of from 36% to 97%. Samples were annealed for periods of $\frac{1}{2}$, 1, 2, 6, 12, and 24 hours at 130°, 155°, 170°, 180°, 205°, 230°, and 280° C., and for half an hour at 330°, 450°, 650°, 750°, and 850° C. Mean breaking loads after each heat-treatment, frequently and carefully checked, are given.

It is found that the annealing behaviour depends not so much on the original tensile strength of the wire as on the amount of reduction by cold-work which it has undergone ; to express this in a form convenient for diagrammatic representation, the "work ratio"—diameter at intermediate annealing divided by final diameter—is used.

The more lightly drawn wires show an appreciable increase in strength after annealing at low temperatures. They retain their strength at temperatures up to, say, 250° C., very much better than the harder wires ; the latter begin to soften at temperatures little above 100° C., and the rate at which strength is lost increases with increasing cold-work. The hardest wires all show a definite decrease in breaking load after storage for two years at room temperature ; the more lightly drawn wires show no change. This apparent differentiation is again suggested by the breaking load/temperature curves from 450° to 850° C. ; the lightly drawn wires decrease slightly but steadily in strength with rising temperature, but all the harder wires without exception have higher breaking loads after annealing at 750° C., and again at 850° C., than they have after heating at 650° C.

After all heat-treatments of sufficient severity to effect more or less "complete" annealing, the breaking load is lower the less the amount of cold-work done on the wire, and it increases steadily with increasing cold-drawing until the three most severely drawn wires of all are reached, when there are fairly definite indications of a decrease in the strength of the fully annealed wire.

The importance of these facts from the point of view of any theoretical discussion of annealing phenomena, and conversely in their bearing on the whole problem of hardening by cold-work, is evident.

## Thermostatic Metals

ONE important development in the use of electric heating appliances is the tendency among manufacturers to make more use of automatic temperature-control devices. Accurate automatic temperature control has had a very great influence on the development of industrial electric heating, but in this field high temperatures are involved, and temperature control is usually accomplished by the use of suitable pyrometric instruments operated by thermo-couples. In the case of lower temperatures, such as water or air heating, accurate control is possible by means of a thermostat, which is usually quite a simple device incorporating a length of thermostatic metal.

Although details of design vary considerably the operation of these thermostats depends on one fixed principle, that is, the difference in lineal expansion between two dissimilar metals. These two metals have, respectively, a low and high coefficient of thermal expansion, and the low-expansion material is invariably an alloy of nickel and iron having a nickel content of approximately 36% ; this alloy being familiarly known as Invar.

Such dissimilar materials as these may be rolled together by a special process to form compound metal or bi-metal strip. Various combinations of metals have been produced with success, and the high-expansion metal may be brass, mild steel, Monel metal, or other metals depending upon the characteristics required.

The fact that the two sides of the bi-metal strip expand or contract to different degrees with changes of temperature results in a distortion or bending of the strip one way or the other. This distortion is used to move contacts either in the heating circuit or, in the case of heavy currents, to operate relays. Whether the thermostat contacts are in the main circuit naturally depends on the current carried ; but if this is too high to be carried safely by the thermostat itself it is a simple matter to introduce a relay which is operated by the thermostat, and which, in turn, opens or closes the main circuit.

The continual expansion and contraction results in considerable strain in the bi-metal strip, and unless the joint between the two metals is perfect the resulting distortion quickly causes them to tear apart. The special method is therefore necessary in the bi-metal manufacturing process which ensures an absolutely rigid and permanent union between the two metals, and this fact plays a great part in producing bi-metal strip which will give accurate and consistent results over extremely long periods of use.

To some extent the accuracy of bi-metal thermostats depends not so much on the actual amount of movement with change of temperature as consistency of movement through the whole temperature range for which the instrument is designed. With this in mind special combinations of bi-metal have been developed for accurate work—a well-known one being Invar and a 21% nickel-iron alloy. Special heat-treatment is advisable in some cases to ensure consistency of results.

An interesting feature of bi-metal is that it can be bent or worked into suitable shapes according to the design of thermostat, any changes of temperature producing a movement in the bi-metal element in keeping with its original shape. It is not possible to mention every type of thermostat incorporating bi-metallic strip, but it is important to know that when designing an instrument it is often possible to calculate the exact amount of movement in the element for a given change of temperature.

Thus, with a straight bi-metal strip, held as a cantilever at one end, the deflection at the free end varies as the square of the length and inversely as the thickness. Where L is length of strip $\alpha$ is difference in mean coefficient of expansion of the two metals over temperature range required. T degrees change in temperature. H is thickness of strip. X (deflection at free end) $= \dfrac{3\,L\,\alpha\,{}^{2}T}{4\,H}$

It follows that when the bi-metallic strip is used in this form greater sensitivity is obtained when the strip is long and thin.

# METALLURGIA

## *The British Journal of Metals*

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

# TRADE IMPROVES SLOWLY

## Reciprocal Agreements will Facilitate Trade Progress

THE Board of Trade returns for August show further signs of improvement in trade, and these, together with the evidence of recovery shown in the returns of the previous month of the year, tend to justify the impression that British trade has overcome the worst of the depression and is now slowly making headway. It should not be assumed, however, that trading conditions are anything like normal yet; the number of unemployed has certainly been reduced, but only to a relatively small extent, and a greater proportion will need to be absorbed in useful work before it can be stated with truth that we are experiencing a trade revival. Still, it must be remembered that August is a holiday month, and in spite of a certain amount of disorganisation inseparable from holiday the returns show an upward tendency. This is a very hopeful and encouraging sign.

The imports during August totalled £56,754,458, an increase on the July returns of £3,048,231, and on August, 1932, of £3,432,077. The exports were £30,996,748, an advance of £1,149,408 on July, and of £2,444,962 on August, 1932. It is interesting to note that the major part of the increase in imports comes under the heading of raw materials and articles mainly unmanufactured, while practically the whole of the increase in exports is accounted for by articles wholly or mainly manufactured. Unfortunately the improvement in not evenly distributed over the many trades concerned, some of these have not yet felt any benefit from it, but under the 20 classifications of the export trade, 15 showed increases, and five decreases, when compared with the trade in August last year. The principal increases were non-ferrous metals and manufactures, which showed a marked improvement of £824,112; iron and steel and manufactures with an increase of £183,447; vehicles, including locomotives, ships, and aircraft, showed an increase of £192,714.

There are, however, several disappointing features about the returns, notably cotton, which is fighting for its existence against strong Japanese competition in many markets. Machinery, also, is finding difficulty in securing markets overseas, while ships are not being built to anything like the extent that was formerly customary, although there are definite signs of improvement in the shipbuilding industry. Several orders have, for instance, been placed during the last few weeks; these should materially assist in relieving the depression so prevalent in this industry, while the prospects of an early resumption of work on the Cunarder is brighter. In regard to coal, an industry which has also suffered from severe depression, European markets are being gradually recovered and, apart from the slump in exports to Ireland, the industry is just about holding its own in comparison with last year.

A gratifying sign is the considerable reduction in the imports of semi-finished steel in the form of billets, blooms, and slabs. Arrivals of sheet and tin-plate bars, formerly a considerable trade, have shrunk to comparatively small proportions. The finishing trades in this country are now getting practically the whole of their supplies from steel-makers at home. Thus British works are supplying substantial quantities of semi-finished steel which formerly was supplied by Continental workers. The position is much more healthy in the iron and steel industry than last year at this time. A considerable increase in pig iron has been necessary to meet demands and several blast-furnaces have been restarted. The reorganisation so far effected in this industry is having considerable influence on the market. The reduction in production by Continental firms and the increased production by home firms have to some extent adjusted the economic balance, as the former have found it necessary to raise prices to a level at which home producers are in a better position to complete.

Although the exports from this country are not as favourable as they might be the Board of Trade returns do not complete the information. Many industries that are finding it difficult to export because of tariffs are increasing their business at home. While this is a good sign, in view of the barriers raised against our trade in nearly every market abroad, any considerable revival in trade is dependent upon exports, and these can only be increased by removing the obstacles that retard development, and there is ample room in this direction for the Board of Trade to facilitate export trade. Greater use should be made of the fact that Britain is a great importing country. Reciprocal trade should be insisted upon to a greater extent and the balance adjusted on an equitable basis.

It is true that agreements entered into with other countries have not yet been in operation long enough to show their effect on returns, but if the Government will direct their attention to the adjustment of prohibitive tariffs, the removal of restrictions on normal trading facilities, and the development of the policy of buying from countries that take a corresponding proportion of our goods, the general improvement which is manifest may well continue and develop into a trade revival. Greater development in this direction would have a considerable influence in bringing about a return of confidence in capital expenditure—on projects such as has been decided by Imperial Chemical Industries for the manufacture of petrol from coal for instance—it would then have a cumulative effect and hasten the return to employment of vast numbers of people that are deteriorating both mentally and physically through lack of work.

An interesting suggestion was made by Sir Alan Garrett Anderson, president of the Association of British Chambers of Commerce, recently. Though agreement on world policy may be impossible through the activities of an international conference, he sees the possibility of achieving the common objective through a club of world trade in which the members are bound together by an exchange of mutual trade concessions. This, he suggests, may do everything the World Economic Conference failed to do—*i.e.*, enlarge the flow of world trade for the benefit of all the individual members. This, of course, is another method of developing reciprocal trade agreements. Whatever method may be adopted to achieve the ultimate end there can be no doubt that, under present conditions, equitable arrangements with individual countries for reciprocal trade will enlarge world trade.

## The Value of Scientific Investigations to Industry.

THE meetings of the Iron and Steel Institute and the Institute of Metals indicate one of the most encouraging signs in British industry. They show to what extent research work is in progress throughout the various industries represented. The amount of time, money, and thought applied to the solution of engineering problems, and to development in the various fields represented in these depressing times, is a happy augury for the future. That there is ample need for continuing the policy is generally appreciated. It is only possible to maintain a progressive position by retaining the initiative obtained as a result of steady and persistent study of the many problems that continually arise. Discoveries are few in the metallurgical field, and when they do happen they are generally the prelude to much research before they can be profitably applied, and, as a rule, the field is so vast that the work of weeks and even months is necessary to obtain a right conception on one minor detail in the theory evolved with the object of applying it in practice.

At both these Institute meetings considerable reference was made to the great strides in metallurgy during the present century, both in ferrous and non-ferrous metals. The advances are really represented by advances in the various branches of engineering because engineering science and practice were just as successful as the available materials will allow. At the beginning of the twentieth century, as Sir Harold Carpenter said, when the members of the Iron and Steel Institute were officially welcomed at the Mappen Hall, Sheffield, the motor-car was in its infancy and the aeroplane was an experimental toy. The mechanical and electrical industries were of minor importance in comparison with what they are now. In addition to mechanical and electrical engineering, special mention might also be made of chemical engineering which has made so much progress during this relatively short time. The automobile and aeronautical industries in particular have been responsible for the extension of alloy steels and of aluminium alloys, and they have also been responsible for great advances in such processes as drop forging, tube making, and sheet pressing.

Sir Harold Carpenter made special reference to high-speed steel, the first paper on which was published in 1904, and stated that Sheffield, by the extent and quality of its knowledge, was able to take advantage of the discovery and constitute itself one of the chief centres for the production and manufacture of that steel. He also mentioned stainless steel, associated with the name of Mr. Harry Brearley, which has been developed to such a high standard, but only as a result of incessant research. The development of creep- and heat-resisting steels, associated with the name of Mr. Dickenson, is of more recent origin, but it has been the subject of intensive study all over the world and the employment of metals at elevated temperatures has entered a new phase. The manufacture of alloys that resist creep and oxidation has advanced and heat-resisting steels are now giving satisfactory service at temperatures unheard-of ten years ago. The strides made in the development of non-ferrous metals and alloys is not less important, particularly aluminium alloys, in regard to which it is doubtful whether more rapid progress has been made in any other metallurgical field. The knowledge available in this section of metallurgy only 20 years ago was very small and unreliable, but the change that has been effected in the intervening time is remarkable, for it can be said that the phenomenal speeds achieved on land and sea and in the air have only been possible as a result of increasing the power-weight ratio, for which aluminium and its alloys are largely responsible. The development in this field is the more noteworthy since it has emanated from laboratory investigations conducted primarily to improve the knowledge formerly existing on the subject. The discovery of alloys that were susceptible to heat-treatment led to a systematic study of the underlying causes and resulted in the development of many alloys that could be modified at will. This development has been largely responsible for the remarkable increase in the application of aluminium and its alloys.

Although remarkable developments have been effected and applied to industry economic considerations have led to improvements in practice in various metallurgical fields that necessitated considerable investigation. Of these particular mention should be made of various types of furnaces, which have been developed to a high degree, and to the more economical use of fuel in iron and steel plants, examples of which were given in papers before the Iron and Steel Institute by Messrs. W. J. Brooke, W. B. Baxter, and Arthur Robinson.

It has only been possible to refer briefly to a few of the many developments for which scientific investigations are largely responsible, but sufficient to indicate their value to various industries, and it is gratifying that British interests continue to retain the initiative in progress and that developments are rapidly absorbed by industry to meet ever-increasing demands.

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## Empire Marketing.

ANYONE who has read the recent report of the Empire Marketing Board cannot fail to be impressed with the work that has been accomplished. As in previous reports the Board was able to announce new records of shipments of a variety of Empire products to the United Kingdom, notwithstanding the difficult times through which we are passing. In view of the high degree of praise accorded to the Board for its work by all who have had any connection with it, the decision to terminate its operations was received with regret. It is claimed by some that had reasonable time been allowed in which to consider the matter adequately, it is questionable whether the overwhelming case for continuing the Board would have been rejected.

But is it not time that a halt was called to the spending of money obtained from British taxpayers in order to support propaganda designed specially for the sale of Dominion produce in preference to any other produce? It is not promoting the best interests of the British Commonwealth of Nations for Britain to find all the money for enterprises that are distinctly beneficial to the Dominions, without any reciprocal action.

For seven years Britain has borne the whole cost of the work of the Empire Marketing Board, and at the Ottawa Conference none of the efforts made to obtain financial support from the Dominions were successful. In the light of the new position which confronted the Board after the Ottawa Conference, it was necessary to make a close scrutiny of commitments and expenditure. For this purpose a special committee was appointed by the Secretary of State for Dominion Affairs, and the circumstances have dictated a restricted programme of maintenance and the postponement or withholding of support for any new activities.

Although much money has been expended on propaganda, the bulk of the Board's activity has been directed to the promotion of scientific research likely to be of value to the whole Empire. Splendid work has already been done, and it was hoped that those Dominions that have profited most from the various activities of the Board would have appreciated their responsibilities and given the support necessary. The loss will certainly be a serious one for the Dominions, particularly as Britain is their most important market, but the position will be more serious for the colonies, because they are less able to organise special campaigns in the British market.

It is hoped that the Board was able to make some arrangement so that the valuable films it had prepared will continue to be available for schools. These were prepared with the assistance of the various Empire Governments and their educational value is very considerable.

# Faraday and his Electrochemical Researches

*The researches of Faraday gave the science of electrochemistry a firm foundation, and the Electrochemical Society honoured his memory at its recent meeting held in conjunction with the Century of Progress International Exposition at Chicago, when Professor R. S. Hutton gave the second Joseph W. Richards Memorial Lecture in commemoration of the hundredth anniversary of the discovery of the two basic laws of Faraday.*

RELATIVELY a poor man, Faraday's remarkable ingenuity rapidly gained for him a foremost place amongst the scientific workers of the nineteenth century. The son of a blacksmith, he was born in London on September 22, 1791. For a short time he was apprenticed to a bookbinder, but, subsequently, became assistant to Sir Humphrey Davy at the Royal Institution, commencing in March, 1813. About ten years later he became director of the laboratory, and in 1833 he was made Fullerian professor of the Institution for life. To appreciate the work of Faraday it is necessary to consider the world's conditions a century ago, and, in his address, Professor Hutton gave one or two illustrations.

Probably the most interesting part of the address is that in which reference is made to Faraday's method of work and his electrical researches. Professor Hutton emphasised the fact that Faraday was, above all, an experimentalist, but he combined with great manipulative skill an unusual habit of methodically recording the notes of his observations and a fertile imagination duly controlled by experiment and by skilful judgment.

His method of work is now clearly exposed in the reproduction of his laboratory note-books or diary, the publication of which is in progress. Day by day he noted down the experiments performed and the ideas upon them which were passing through his mind. His bibliographical references show that he kept in touch with other cognate work in England and abroad. Despite his high capacity for visualising the fundamental principles of the phenomena he was studying, Faraday was never happy unless he could subject his ideas to experiment and demonstration. He even records that the work of others was never quite clear to him unless he could repeat it with his own hands.

Faraday never used formal mathematics and, in consequence, somewhat mystified his mathematical contemporaries, but both Clerk Maxwell and Helmholtz, who in later years did so much to bring Faraday's work to fuller fruition, record that undoubtedly he possessed a mathematical mind and carried through such of his work as required it on strictly correct mathematical principles, however different from the traditional methods of the time they may have been.

Another marked intellectual capacity which helped Faraday greatly in his work was the rare gift of being able mentally to picture space relationships, as, for instance, in his "lines and tubes of force" so often brought into use in his electromagnetic researches. Faraday's genius for finding the correct solution through the maze of mysteries he was investigating has rightly given him a foremost place amongst scientific investigators. As Kohlrausch said of him, "Er riecht die Wahrheit" (He scents the truth) in all that he studied.

There seems little doubt that the start of Faraday's great work was the construction, when a poor bookbinder's apprentince in 1812, of a voltaic pile with seven halfpence, seven discs of sheet zinc, and six pieces of paper moistened with saltwater, with which he decomposed sulphate of magnesia, as described in a letter to his friend, Abbot, on July 12, 1812.

It was only after a vast amount of chemical work which embraced important discoveries—the liquefaction of chlorine, the isolation of benzine, the preparation of alloy steels, and special glasses—that Faraday started his electrical researches. He was impressed with the relation of magnetism to electricity, and, stimulated by the idea of the convertibility of the different forms of energy which ran persistently through his work, he tried again and again to generate an electric current from permanent and electromagnets. In 1821 and again in 1824, 1825, and 1828 we find him persevering in this search. It was not until August 29, 1831, that he was first able to detect induced currents, and after ten days of intensive work he gave the world his crowning discovery of electromagnetic induction.[1]

Excited and stimulated by this work Faraday dedicated his life to further electrical research. In 1832 he carried out a methodical study of the "Identity of the Electricities." Although the work of Wollaston and others had left little doubt that frictional electricity ("Franklinic" or "common," as Faraday called it) and voltaic electricity only varied in the quantity and intensity in which they generally appeared,[2] the proofs were not precise enough to settle the question, or satisfy the high standard which Faraday himself demanded. This particular investigation is of interest as it embodies a great deal of important electrochemical study. Measurements were made of electrolysis by electric current from diverse sources, the strength of the currents were measured by the deflections of an astatic galvanometer, the electrochemical composition being noted on a variety of materials. Finally, Faraday convinced himself that electricity from the most diverse sources was identical, and published a table to summarise his conclusions.

During the year 1833, and the first half of January, 1834, Faraday was mainly occupied with the study of electrolytic decomposition, and, as usual, planned and varied his experiments widely to test and demonstrate the prolific ideas which were passing through his mind. Some quotations from the Diary and from the seventh series of his "Experimental Researches in Electricity," which were given by Professor Hutton, reveal the outstanding points, and illustrate his method of working and the results achieved.

In this short space of time, by January, 1834, Faraday had laid the foundations of theoretical and applied electrochemistry. The seventh Series of his Experimental Researches published in January, 1834, represents his most important contribution to electrochemistry. He established the first law and formulated the second law of electrolysis.

In establishing these laws Faraday exhibited his extraordinary genius in utilising experimental work with proper interpretation of its quantitative results. He duly noted the great complications caused by secondary reactions at the electrodes; and by their detailed study was able to understand to what degree they affected in some cases his simple laws. Without such genius the validity of these laws might for long have been hidden from us.

In his concluding remarks Professor Hutton stated that Faraday himself was wide awake and keenly interested in the practical applications of science, but with the rare spirit of the true philosopher restrained himself from spending his own time on the larger-scale development of his results. For instance, in connection with his magnetic electrical machines he records: "I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained; being assured that the latter would find their full development hereafter."

1 The Faraday centenary celebrations, held in London in 1931, were dated to commemorate this event whilst embracing his other discoveries. The exhibition of historical apparatus and the sections illustrating the modern developments which have followed from his work, formed an important part of these celebrations.

2 J. G. Childrem, Phil. Trans. Royal Soc., 1815, p. 363, describes the construction and use of a large battery with plates 6 ft. × 2 ft. 8 in. (183 × 81 cm.), hoping that on this larger scale the voltaic cell would give more powerful effects.

# The X-Ray Inspection of Aluminium Alloy Welds

By N. C. HYPHER, B.A., B.Sc., D.M.R.E.(Camb.)

*Consulting Radiologist, High Duty Alloys, Ltd., Slough, Bucks.*

The application of aluminium alloys to aircraft and automobile construction is increasing the need for reliable welds, and in this article the author discusses the uses and limitations of direct X-ray inspection of welded joints.

THE X-ray inspection of iron and steel welds has been carried on at some length in this country, on the Continent, and in America; but little work has been done on the inspection of aluminium alloy welds by the X-rays. It is well known that certain aluminium alloys such as duralumin, the Y, and the R.R. group, which possess high power to weight ratios, are replacing steel in certain parts of aircraft and automobile construction. These alloys also replace wood where wood was formerly used in aeroplane construction. Parts composed of such aluminium alloys can be satisfactorily welded together, and in this article the uses and limitations of direct X-ray inspection—*i.e.*, radiography—of welded joints is set forth and discussed.

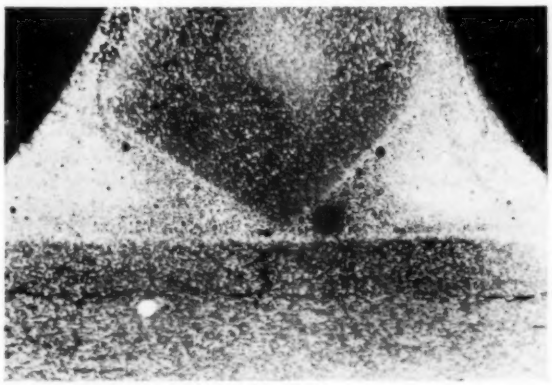


*Fig. 1.—Macrophotograph. Mag. × 70. Butt weld with bevelled surfaces filled in with aluminium-silicon alloy welding material. Note minute circular gas pockets and intercrystalline cracks in base metal.*

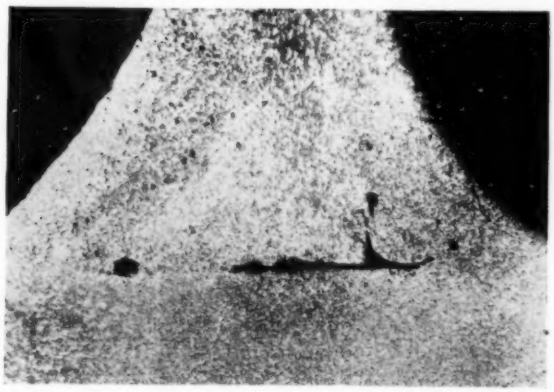


*Fig. 2.—Square butt weld with angles built up with parent metal. Note incomplete union and gas pockets. Macrophotograph mag. × 7.*

It should be indicated here that the high-duty alloys examined were composed mainly of aluminium with very small quantities of other metals. The R.R. series of alloys, for instance, contain very small percentages of copper, nickel, magnesium, iron, silicon, and titanium.

The welds were produced by two methods, namely, the oxyacetylene and the electrical "spot" method. In the oxyacetylene method either aluminium-silicon or parent metal was used to fill the space between the parts to be joined, and the flux (to prevent oxidation) consisted of lithium chloride, 15%; potassium fluoride, 7%; potassium bisulphate, 3%; potassium chloride, 44%; sodium chloride, remainder.

In the electrical "spot" method of welding, thin parallel strips of sheet metal are allowed to overlap at the edges, and at definite intervals the sheets are fused together by the heat of the current passing through electrodes on opposite sides of the double layer. These electrodes grip the strips of metal together. No outside material is introduced, and as air is excluded at the points of application no flux is necessary to prevent oxidation.

Depending on the technique employed the X-rays can produce pictures showing good detail through varying thicknesses of alloy up to 6 in. Most welded joints come within this range of X-ray penetration. The welds we inspected did not exceed 3 in. in thickness, and were easily radiographed with a current of 90,000 volts passing through the X-ray tube.

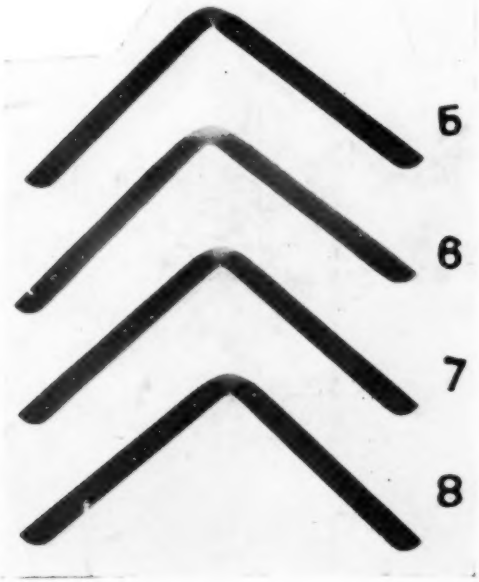



*Fig. 3.—X-ray photograph of specimens Nos. 5, 6, 7, and 8. Angular welds of duralumin with aluminium-silicon welding material. Note the difference in density between the two types of alloy. No defects can be seen.*

The defects which may arise in welded joints are known. These are lack of fusion and union, gas pockets, seams and cracks, and inclusions of oxide and slag. The welded joint also possesses the characteristics of cast metal, and the weaknesses inherent in cast metal occur at a joint made between two pieces of forged metal. This may be partly remedied by suitable heat-treatment, or cold working.

Taking the last first, the feature in the X-ray picture, suggesting cast material, is a mottled appearance, which can be identified after a little experience in the reading of radiographs. Gas pockets appear as round, black spots in the negative, and are readily shown. Failure of union also shows up as a dark space between the opposing metal parts, but only if the parts are not too closely applied together and if the X-ray beam is parallel to the plane of union.

*Fig. 4.—X-ray of a long, angular weld. The junction appears as a white line. No defects can be seen.*

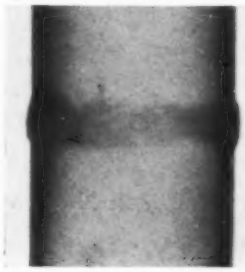


*Fig. 5.—X ray of a sound tubular weld, No. D 2, R.R. 56. The increased shadow at the weld is due to piling up of the material at the weld.*

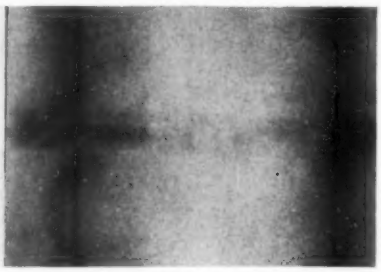


*Fig. 6.—X-ray of the same specimen, D. 2, with a film placed within the tube. No defects can be seen. R.R. 56.*

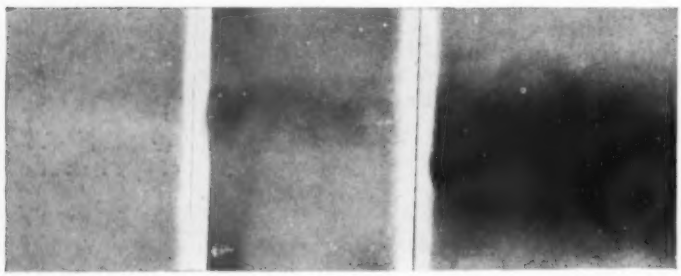


*Fig. 7.—X-ray photographs of varying thicknesses of welded joints. These appear to be sound.*
*Note the effect of piling up the welding material, specially marked in specimen G. G. is an overlapping weld, whereas E and F are end-to-end welds.*

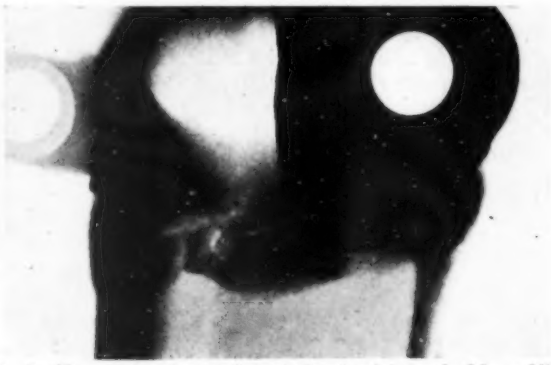


*Fig. 8.—X-ray of a fractured strut (Duralumin) repaired by welding. There are no gas pockets or further cracks. The original line of fracture can be seen as the welding material filling it is lighter in density than the original duralumin.*

*Fig. 9.—X-ray appearances of spot welds on a double layer of aluminium.*

*Fig. 10.—Electrical spot weld on duralumin sheet. Junction of sheets. Not heat-treated. Unetched. Mag. × 30.*
*Very small cracks are seen perpendicular to the line of fusion.*

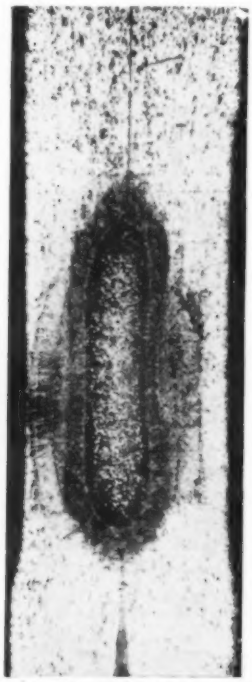


*Fig. 11.—Junction of sheets. Not heat-treated. Etched in HF and $HNO_3$. Mag. × 30.*
*Note the fusion and breaking up of the original structure at the centre, also radial arrangement of the outer crystals by the electric current.*

*Fig. 12.—A soldered end-to-end joint between two pieces of duralumin.*
*Note the dense shadow cast by the soldering material which contains elements of higher atomic weight than aluminium. The material is evenly distributed.*

Continued on page 148

# Oxygen in Cast Iron*

By William F. Chubb, B.Sc.

The author discusses ths general influence of oxygen on cast iron, in the light of published work on the subject, in order that the effects of deoxidisation may be more clearly understood.

SINCE the first moment that oxygen came to be regarded as an almost inevitable constituent of both pig irons and cast irons, the amount of work done in both laboratory and the foundry purporting to show that the general influence of that constituent has been enormous in almost every country of the world. Correlation of these results is by no means easy, for the reason that research metallurgists have in almost every instance been largely confined to studying the problem from their own particular point of view as decided by local operating conditions. The general influence of oxygen may, however be considered in the light of the published work on the subject.

At the outset it must be clear that the presence of oxygen in pig iron and cast iron results from contact with oxygen-bearing gases in the melting zone of the blast-furnace and cupola. Hence, it is of primary importance to define as nearly as possible, or as nearly as the available evidence will allow, the relationship which must be considered as existing between operating conditions, such as amount of blast input, with output and temperature of metal. Research on these lines has been conducted by many workers, and of the results presented for discussion those of Oberhoffer and Piwowarsky (*Stahl u. Eisen*, 1927, vol. 47, pp. 521-533) are worthy of first mention, since they may be justly regarded as the pioneer researches in this direction. Experiments were conducted to define how far oxygen content in pig iron and cast iron was related to blast-furnace operating conditions and reactions, and to melting conditions in the cupola. The results indicate that in the examination of twenty kinds of coke pig no relationship existed between melting conditions and oxygen content, the mean oxygen content of these samples being 0·022%. On the other hand, 14 varieties of charcoal pig iron showed that as silicon content increased so did oxygen reveal a corresponding increase also. In cupola-melted cast iron the results from 30 samples examined gave an average oxygen content of 0·038%, and extensive researches, having for their object the determination of the influence of oxygen upon the resulting product, suggested that a content of 0·045% must be regarded as the maximum allowable. Of the other gases present, those of hydrogen were reported as 19·5, 13·5, and 15·2 c.c.'s per 100 grms. of iron in charcoal pig, coke pig, and cast iron, respectively. These results clearly indicate the importance of the relationship between operating conditions and output and temperature of the metal.

Further work of a somewhat similar character is also worthy of mention. Eckman and Jordan have shown that from examination of coke and charcoal pig the latter is in general much stronger than coke pig iron, but at the same time these authors do not agree that this property results from a higher oxygen content in the stronger iron. In regard to grey cast iron they report that their experimental results fail to convince them of any strengthening influence of oxygen content.

Continuing their work upon oxygen contents, Oberhoffer and Piwowarsky (*Iron Age*, July 14, 1927) concluded that Johnson's theory of oxygenation in pig iron and cast iron was untenable, being, as they think, based upon incorrect premises. For pig irons, they obtained oxygen values of 0·010 to 0·035%, and for cast irons 0·025 to 0·060%. Contrary to their earlier statements, these authors concluded that oxygen and silicon contents bear no relation to one another, nor do they consider that oxygen bears any relationship with general chemical composition, a view not universally held. Indeed, it seems clearly to be established that the additional oxygen content in cast iron must be derived from contact with oxidising gases in the melting zone of the cupola. As to mechanical properties in the resulting irons, Oberhoffer and Piwowarsky claim that with contents up to 0·035% oxygen had little or no influence, nor is the deterioration at all pronounced until a percentage of over 0.045 has been reached, when the irons become definitely inferior.

From the belief that oxygen is absorbed during the passage of the molten metal through the melting zone while in contact with gases, one would be led to infer that the introduction of oxygen-bearing gases into the blast, and even oxygen itself, would effect an increase in the total oxygen content of the iron. Experiments conducted upon these lines, however, do not endorse these expectations, and it would, therefore, appear that any modification of working conditions which is designed to increase the superheat of the metal tend towards a reduction in the oxygen content and toward the production of more satisfactory iron. In these results are shown the practical value of these researches to the foundryman, for they clearly demonstrate the necessity for melting hot, so that should oxygen be absorbed beyond the considered safe limit of 0·035%, then it may be lowered again by the deoxidising effect of higher melting temperature.

While these researches have covered the direct influence of oxygen, there still remains to be considered the indirect effects resulting from its modifications of the influences exerted by other constituent elements, and in this connection much useful work has been accomplished. Of the results so far presented probably those of Bardenheuer and Zegen (*Giesserei*, 1928, vol. 15, November 9, pp. 1,124-1,128) are amongst the most important. In reviewing the effects of oxygen upon mechanical properties of cast iron, these authors have conducted experiments which by their results suggest that deoxidation by ferro-titanium raises the graphite content, thus bringing about a general lowering in strength and ductility. Further, they argue, that only in annealed chilled irons does deoxidation by this reagent give any increase on elongation. Other results of this research are worthy of mention for they observe that sulphur has a much less marked influence in a deoxidised iron than in an untreated iron. For instance, in the deoxidised iron its bad effects are stated to be hardly perceptible until a content of 0·27% is surpassed. As to other elements, it is claimed by these workers as well as by many others that phosphorus, far from bringing about a degeneration of properties, has a very favourable influence upon the deoxidised metal in amounts up to 0·3%, when tensile strength reaches a maximum. At higher phosphorus content, however, this property is consistently lowered.

In reviewing the published results, and in considering more particularly those of Oberhoffer and Piwowarsky, it is clearly necessary to determine in what form or forms oxygen may and does exist in both pig irons and cast iron, and to establish further the extent to which each form may be present. Such knowledge should suggest in what manner these constituents are likely to be changed in passing through the cupola, and hence to what extent they may be expected in the resulting product. In steel, oxygen may exist in a number of different forms, for instance, as silica $SiO_2$, ferrous oxide FeO, oxide of manganese MnO, or

*Continued from page 123 August issue.

as the oxide of any deoxidant employed—*e.g.*, as $Al^2O^3$. Theoretical calculations cannot, however, readily be made from general chemical compositions, even when total slag content has been experimentally determined. For this reason, as well as for other reasons, it becomes necessary to rely upon analytical methods to determine the extent of each oxygen-bearing constituent, and this aspect of the work is by no means straightforward. Indeed, some of the published results are open to criticism, as are some of the analytical methods sometimes used. Much of the work has been conducted from borings, and particularly has this been the case with oxygen determinations. Consequently, total oxygen figures reported have frequently been considerably higher than the expected values on account of the known adsorption of air by the graphite present. Careful experimental work by Herty and Gaines in the United States on pig irons from the blast furnace has shown oxygen-bearing constituents totalling 0·13% of the total iron.

For confirmation of these results one may again refer to the work of Oberhoffer and Piwowarsky, and of their co-workers. In experiments upon Swedish charcoal iron and upon cupola-melted cast iron, it was found that most of the oxygen was present as silica, and that the excess of oxygen in cast iron produced an increase in this constituent. By the method of extraction of residues by bromine, the residue other than iron was, in the samples examined, 0·036%. Of this the oxygen content averaged 0·022%, with 0·013% of silica. It was observed also that it was not produced to the same extent in coke pig iron, presumably owing to the fact that the lower temperature of the charcoal iron furnace does not result in a complete reduction of silica to metallic silicon, as in the hotter coke irons.

Enough has been said of the mode of occurrence of oxygen in cast iron to render more clear the effects of deoxidation, but it is here necessary before proceeding to a discussion of deoxidation methods, to summarise the general influence of this element upon the metal. Because oxygen only has been considered in this review of the subject it must be clearly emphasised that it is not the sole gaseous constituent in either pig irons or cast irons, for both nitrogen and hydrogen have been reported, and, indeed, are to be expected in these materials.

Of its influence on the liquidus and solidus lines in the iron-carbon diagram little is known within the region of the cast iron analyses, but it seems clearly established from the discussion of low carbon alloys that the present views of equilibrium conditions requires modification in certain respects on account of the presence of oxygen. The present author feels that further research upon this subject is necessary, despite the considered opinion of many eminent authorities that elemental oxygen can hardly exist in liquid iron. In its influence upon microstructure one must agree with the views of Oberhoffer, formed from his very practical and useful researches, that division of graphite is not due to oxygen but to a higher degree of superheat applied, and, further, that Johnson's theory of oxygenation has not been substantiated by subsequent work upon that subject. Of its influence upon the mechanical properties of cast iron and pig irons it seems clear that this will depend more upon local operating conditions than upon a mere question of oxygen content.

In the third of these articles it is proposed to consider in some detail the methods available for reduction in oxygen content, and to indicate in each case what changes or modifications in physical and mechanical properties may be expected.

## Institution of Welding Engineers.

The North-western Branch will open the winter session on September 27, when "Experiences of Practical Welders" will be given by Messrs. W. Billingham, W. W. Ely, C. Peat, and E. W. Hart. The meeting will be held in Manchester College of Technology.

## The X-Ray Inspection of Aluminium Alloy Welds.

(*Continued from page* 146.)

If aluminium-silicon is used as the welding material this casts a less dense shadow than the R.R. or "Y" alloys, and the width of the weld can be easily determined (Fig. 4). Where parent metal is used this space cannot be distinguished.

Shrinkage cracks may occur in welds owing to the great differences in temperature during heating between different parts of the weld, and the stresses set up during the process of cooling. These will only appear in the radiograph if they lie in a plane nearly parallel to the X-ray beam. We have found that defects do not usually occur singly. For instance, where gas pockets only are revealed by the X-ray shrinkage cracks may also be found by sectioning and macrophotography to be lying in a plane incapable of proper demonstration by the X-ray. Similarly, layers and seams due to incomplete fusion will only appear if they lie in a direction parallel to the X-ray beam.

Small slag and oxide inclusions, such as may occur in welds, are not shown up readily. Herein lies a feature of contrast between the X-ray inspection of steel and aluminium welds. The aluminium oxide and slag inclusions possess a density very near that of the aluminium alloys, and as density and relative opacity to the X-ray are synonymous such inclusions will not be revealed unless they are pure (unmixed with alloy) and large. In the case of steel welds, the differences in density between the slag or oxide inclusions and steel are great, and the resulting contrast is easily shown in the X-ray picture.

On the other hand, bad welds occur far more readily with iron and steel than with the aluminium alloys. This feature can be explained. The aluminium alloys melt readily at moderately high temperatures, and union follows ready fusion. If a sufficiently high temperature for the melting of steel is not attained lack of fusion occurs and non-union. Higher temperatures are necessary for the fusion of steel, hence there is a greater liability to oxidation, gas pockets, and cracking on cooling. I have seen numerous pictures of steel welds, and it appears that gas pockets are a common fault. By the oxyacetylene method good aluminium welds are readily made under $\frac{1}{8}$ in. in thickness. Gas pockets, however, may occur in thicker specimens.

In the case of the electrical "spot" welds radiography is of no value for detecting faults. The parallel sheets of metal are welded together at several spots, and the only feasible direction of examination by radiography is at right angles to the plane of the sheets. This will not tell whether the sheets are satisfactorily fused together at the spots. Macrophotography is of great value here as a method of research, as it clearly indicates the character of the weld. Its disadvantage lies in the fact that it is a destructive method, as it involves a preliminary sectioning of the finished weld. The tensile test is also of value for testing welds, but here again it involves the destruction of the weld. These two latter methods give considerable information about particular types of welds, although they cannot be used as a routine.

A further non-destructive method of inspection which promises to be of value in the examination of metal structures and welds is the X-ray diffraction picture obtained by reflecting a pin-hole beam of X-rays at the surface of the point to be inspected. This method is at present in a research stage, but promises to be directly applicable to the determination of states of stress in metal parts and welds, without the necessity of breaking up the specimen.

I am indebted to Mr. Robinson, of High Duty Alloys, Ltd., for assistance with the macrophotography, and I have to thank Mr. W. C. Devereux, managing director, for permission to publish this article.

# IRON AND STEEL INSTITUTE

## *Annual Meeting at Sheffield*

THE autumn meeting of the Iron and Steel Institute, held in Sheffield on September 12-15, proved a very successful event. It is 28 years since the annual meeting was last held in Sheffield, during which time great advances have been made in metallurgy. This was commented upon at the official welcome given to the members of the conference by the Lord Mayor at the Mappin Hall. Opportunity was also taken to praise the part taken in the progress by Sheffield metallurgists. Particular attention was directed to special steels in the manufacture of which Sheffield is the world's chief centre. The technical sessions were held in the University, and the members were welcomed on behalf of the University by Dr. A. W. Pickard-Cambridge, the vice-chancellor, who referred to Sir Robert Hadfield's gift of £5,000 to the University. The papers presented at the technical sessions struck a very good balance between the theoretical and practical sides of the iron and steel industry, and those which dealt with the fuller utilisation of fuel in blast-furnace and steel plants attracted much interest.

So much has been said and written during recent years about the inability of the iron and steel industry to produce on an efficient basis comparable with continental practice that the papers presented by Messrs. W. J. Brooke and W. B. Baxter are very opportune. They are not only informative but distinctly encouraging, and show that the unfortunate habit of belittling the activities in this industry is not entirely justified. It must be remembered that the eminence of the British iron and steel industry was built up on cheap fuel conditions, when no economic advantage could be gained by the expense involved on plants necessary to save fuel. Because of this and several other factors the dear fuel period which followed the war, found this country at a distinct disadvantage. It was then that the need for higher fuel efficiency was recognised as of vital importance, and important developments, arising from this need, have resulted in steady progress in the scientific ultilisation of fuel and the gradual reduction in the amount of fuel per ton of product.

### Heat Conservation and Utilisation of Blast-furnace Gas

There are in England modern plants in no way behind the best continental ones, says Mr. Brooke, and on such works he believes the practice is as good as any other, no matter where. Two of the works included in this are the Normanby Park Works and Frodingham Works, both of which are at Scunthorpe. At the former works the co-ordinated heat conservation scheme which is in operation is discussed by Mr. Brooke, while the utilisation of blast-furnace gas at the Appleby Works is discussed by Mr. Baxter.

The possibility of utilising the lean Lincolnshire ores as a means of producing cheap steel was pointed out by Mr. Brooke in a paper presented in 1925. The idea underlying the scheme, which is now in operation, is based on the fact that the low iron content of these ores necessitates the use of a large quantity of coke in the manufacture of pig iron, and provided the coke required is manufactured at a plant in close proximity to the blast-furnaces, the gas from the coke in the blast-furnaces and the rich gas from the coke ovens can be utilised together or separately for all the heat requirements in the making and rolling of the steel made from the pig iron.

Mr. Brooke discusses the factors that influenced the installation of the new plant embraced by the reorganisation scheme, and describes briefly the various plants now in successful operation at these works. The blast-furnaces, it is noted, on account of the uniformity of the screened ore and the good-quality coke produced, now work with extraordinary regularity. There is a marked absence of hanging and slipping, and consequently the gas supply can be relied upon with complete confidence. A subsidiary effect is an increased output of 100 to 150 tons per week per furnace, and in consequence the furnaces have worked with a much lower coke consumption. Instead of 31 cwt. per ton of iron, allowed for in the gas balance sheet, it has often been necessary to make do with gas from under 27 cwt. of coke per ton of pig iron. Indeed, during the past few months two furnaces have been blown in after relining (replacing others blown out) which for months on end have been producing basic pig iron with less than 26 cwt. of coke per ton, with iron content in the burden of 27·5% (excluding coke). The quality of iron produced has been markedly uniform, the sulphur rarely exceeding 0·06% and the silicon 0·7%.

The full use of gas throughout the works and the sale of by-products has enabled steel to be made and rolled for a coal consumption equivalent to 1·506 tons per ton of steel, and the ultimate aim—viz., the reduction of working costs—has been achieved to a quite satisfactory point. As an instance of this, Mr. Brooke states that it is now possible to produce coke at a cost of 3s. 6d. to 4s. per ton less than the price of the slack per ton delivered at the ovens, after giving the usual credits obtained by the sale of sulphate of ammonia, crude benzole, and crude tar, at current market prices. Gas is credited to the extent of the participation of the oven gas in the displacement of coal previously employed, and varies with the amount of steel produced from 3s. 6d. to 4s. per ton of coke. From this it will be readily understood that basic pig iron of the very best quality is now being made at a cost that is less than anything achieved in Lincolnshire since the early days of the present century. In this achievement the workmen at the blast-furnaces have not suffered, as they are now taking home each week between 70% and 80% more money than they did in 1914. The railway companies have contributed nothing, since, in spite of allowances due to de-rating, some 10% more is still being paid for the assemblage of the blast-furnace raw materials than was paid before the war.

At the Appleby Works Lincolnshire ores are also used, and, being of low grade, they require a substantial proportion of coke for their reduction. For many years coke consumptions of the order of 30 cwt. per ton were common. Recent developments in plant and technique have enabled the consumption of coke per ton of iron to be considerably reduced, while they have had the effect of increasing the outputs of the furnaces. In Lincolnshire, therefore, large quantities of gas are produced in proportion to the pig iron made, and there has always been a substantial inducement to make full use of this by-product. How this is being accomplished at Appleby is indicated by the test results which form the seven appendices to the notes given by Mr. Baxter. The tests are chosen as typical examples of the utilisation of blast-furnace gas for various purposes. They were not made under ideal or staged conditions to demonstrate maximum efficiency, but to show what was happening under present-day practice in order to detect where improvements in working might be achieved. The tests recorded in the appendices are as follows :—

Appendix I.—Gas engine generator.
" II.—Slab heating furnace, top-charged.
" III.—Slab heating furnace, side-charged.
" IV.—Normalising furnace.

To make the record of tests more comprehensive the following have also been included from the Frodingham Works :—

Appendix V.—Bloom heating furnace, side-charged.
" VI.—Billet heating furnace, continuous.
" VII.—Water-tube boiler.

The data obtained from the tests collected in these appendices justify the policy of the use of blast-furnace gas and the gradual elimination of coal. The effect of this policy is well shown by the large reduction in the use of solid fuel at the Frodingham Works. The following figures show the consumption of solid fuel expressed in cwt. per ton of ingots produced. They do not include blast-furnace coke, but do include the solid fuel used for all other purposes in the iron and steel works, such as coal for steel furnaces, boilers, locomotives, travelling cranes, and all the smaller consumers.

| | | |
|---|---|---|
| 1913 | : | 17·2 cwt. of coal per ton of ingots. |
| 1924 | : | 10·65 " " " |
| 1928 | : | 7·95 " " " |
| 1933 (half year to June 30,) | : | 7·13 " " " |

The Appleby blast-furnace and steel plant has benefited from the experience gained at Frodingham, and the total consumption of coal for all purposes for the first half of the year 1933 amounted to 4·61 cwt. per ton of ingots, which figure includes the coal used in the melting shop for the production of ingots—namely, 3·35 cwt.

## Factors Leading to Greater Production from a Steel Furnace

The speeding-up of the working of the steel furnace was discussed by Mr. Arthur Robinson in a paper in which he gave particulars of the results obtained with the tilting furnaces of the Appleby Iron Co., Ltd. (subsidiary of the United Steel Co., Ltd.). The plant and process were described in a previous paper[1] and in this communication the author confines himself to a discussion of some problems of general interest and some which have a special bearing on the basic lined furnace.

The factors which control the rapidity of working, with its attending fuel economy, are :—(*a*) Furnace design, fettling and repairing practice, and heating control ; (*b*) charging and casting facilities ; (*c*) quality of raw materials and their mechanical condition ; (*d*) process and practice, and chemical control ; and (*e*) staff. These factors are discussed and the results obtained from the practice, as given in the paper, are a sufficient commentary on its success ; these are given in the following statement :—

| | | |
|---|---|---|
| Average furnace life between repairs .. .. .. .. .. | 39,000 | tons of ingots. |
| Average make of ingots per week over 13 weeks, two 250-ton and one 300-ton furnace .. .. .. .. .. | 6,371 | |
| Best output for four weeks for one furnace .. .. .. | 10,042 | |
| Best output for one week for one furnace .. .. .. | 2,610 | |
| Coal consumed at gas producers (without heating up) .. | 3·14 | cwt. per ton of ingots. |
| Burnt dolomite used for fettling (running repairs) .. .. | 0·45 | |
| Total burnt dolomite used, including general repairs .. .. | 0·50 | |

By following up some of the points discussed, the author states that considerable further progress may yet be made at the Appleby plant in speeding-up the working of a steel furnace. By turning the steel furnace into a more reliable machine it is possible to produce not only more but better steel at a lower cost.

## Effect of Tin as an Impurity in Mild Steels

Considerable difference of opinion exists as to the maximum amount of tin which is permissible in steel without injuring its properties. Yet the whole question of the effect of small quantities of this element in steel is of importance to the steel-making industry, since the use of the cheapest variety of scrap for a large number of products involves the risk of serious contamination with tin. In this paper, by Professor J. H. Andrew and Mr. J. B. Peile, the research was restricted to the investigation of a series of mild steels with a maximum carbon content of 0·3%, and containing varying tin contents, from a minimum of 0·05% to a maximum of 0·63%. The steels were investigated by thermal analysis, mechanical testing, and microscopical examination.

As a result of these investigations, it is stated that, in this type of steel, the presence of tin up to the maximum content employed does not injure the resistance of the steel to tensile stress in any way. Even the smallest amount, however, lowers the shock-resisting properties of these steels, and if the tin content exceeds 0·2% the effect is serious. This effect is much more detrimental if the steels are tempered at a low temperature, or if they are allowed to cool slowly through the range 400°—200° C. after tempering. The ill effect of tin on the impact strength of these steels can be minimised by quenching after a full temper, say, at 620° C.

The way in which tin influences these steels in such a detrimental fashion has not been elucidated. There is a certain amount of indirect evidence, by comparison with nickel-chromium steels and from diffusion experiments, which indicates that thin brittle films of free cementite are formed in the grain boundaries. From purely negative evidence it is suggested that the α solid solution of tin in iron is substantially weaker than pure ferrite ; but this has not been investigated.

## The Influence of Beryllium on Steel

This paper, presented by Mr. J. H. S. Dickinson and Dr. W. H. Hatfield, describes an investigation, and puts on record most of the principal results, carried out jointly in the research departments of the English Steel Corporation and Messrs. Thos. Firth and John Brown, Ltd., at the request of the Air Ministry. The investigation is not claimed to constitute an exhaustive study, in the full scientific sense, of the effects of beryllium on steels in general, as it was limited and severely practical in its scope. The object of the investigation was to determine whether the addition of beryllium to selected types of steel largely used in aircraft and aero-engine construction was likely to offer any direct benefit. A few crucible ingots, each about 50 lb. weight, were considered adequate for the purpose.

The results indicate little prospect of the element beryllium becoming a useful addition to the group of metals used in the manufacture of special steels. The metal is extremely expensive, and is unlikely ever to become reasonably cheap, whilst its lightness and readiness to oxidise make the actual introduction into molten steel somewhat difficult and distinctly wasteful.

The addition of 1% of beryllium tended to make some of the steels, particularly the 3½% nickel and the nickel-chromium steels, distinctly " stiffer " under the hammer, with an increased tendency to " burst," especially towards the top end, but it is probable that this would give rise to no serious manufacturing difficulty if the beryllium steels were required for use in engineering construction because of their desirable physical properties. In this respect, however, the addition of beryllium has proved harmful rather than otherwise.

Apart from a hardness peak in the tempering range 400° to 450° C., and the associated brittleness and the liability to crack with rapid cooling, probably due to some pronounced volume change, the beryllium-bearing steels show throughout a marked liability to fragility, as evidenced by impact test, which far outweighs the increase in tensile strength. In short, none of the steels containing beryllium has shown, with any treatment, the combination of high elastic limit and fatigue resistance with ductility and toughness which is necessary in highly-stressed engine parts. It was thought that the addition of beryllium might confer upon stainless steels of the 18% chromium, 8% nickel type, which are normally austenitic, an increased resistance to corrosion, but in this case also the results were definitely disadvantageous.

[1] *Journal of the Iron and Steel Institute*, 1931, No. 1, p. 57.

## The Constitution of the Alloys of Iron and Manganese

The investigation described in this paper forms part of a systematic research on the alloys of iron which is in progress at the National Physical Laboratory under the auspices of the Alloys of Iron Research Committee. Formerly under the direction of Dr. W. Rosenhain, this research is now under the direction of Dr. C. H. Desch. This investigation, the results of which are given by Dr. Marie L. V. Gayler, is the eleventh of the series, and thermal, microscopical, and X-ray examinations of alloys made from high-purity electrolytic iron and distilled manganese are the means which have been employed to determine the constitution of the iron-manganese alloys.

In comparison with previous determinations, the position of the liquidus and solidus has been appreciably raised as a result of this investigation and the existence of a peritectic reaction between $\gamma$-iron and liquid to form $\gamma$-manganese has been confirmed.

The $\delta$-iron transformation has been found to take place at 1,504° C. over a range of composition of 1 to 8% of manganese; $\gamma$-iron then separates directly from the liquid state until, at a temperature of 1,270° C., it reacts with the manganese-rich liquid to form a phase containing approximately 68% of $\gamma$ manganese. This peritectic reaction extends from 65 to 74% of manganese, after which the $\gamma$ manganese phase separates directly from the liquid on cooling.

The constitution in the solid state of iron-rich alloys has not yet been solved, and has, therefore, not been included in the constitutional diagram submitted.

The changes in the solid state of manganese-rich alloys have been very carefully determined by means of the thermal, microscopical, and X-ray analysis of a number of alloys. The $\gamma$-manganese phase is shown to decompose into $\gamma$-iron and $\beta$-manganese at a temperature of 1,028° C. over a range of composition of 64 to 72% of manganese, and similarly the $\beta$-manganese phase has been shown to decompose into $\gamma$-iron and $\alpha$-manganese at 600° C. over a range of composition of about 59 to 63% of manganese.

The paper includes an appendix by C. Wainwright, M.Sc., on the X-ray structure of manganese-rich alloys quenched from various temperatures.

## A Coke-fired Reheating Furnace

This paper, by Mr. F. Lloyd and Dr. R. V. Wheeler, outlines experiments made with the object of designing a furnace for certain classes of steel sheets and billets which, in addition to providing a reducing atmosphere, would prevent the bed becoming cool during the time of recharging. These experiments were made as part of a programme of work organised by the Joint Advisory Committee of Sheffield, Rotherham, and District Smoke Abatement Committee, and of the Sheffield and District Manufacturers' Committee, the investigators concerned being Dr. H. A. Fells and, later, Dr. J. K. Thompson.

The form of furnace generally preferred is one in which an open bed of lump coal is used, but after several experiments a bed of broken and sized metallurgical coke was found preferable, gas being used for starting-up, and the paper describes a coke-fired reheating furnace on these lines which was eventually designed. The furnace was designed primarily for the hardening of tool steels, and it has been in continuous service for heating small bars of drill steel to 850° C. for hardening. About 200 lb. of steel per hour can be heated with a coke consumption of 30 lb. per hour. This performance naturally could be improved by heat-insulation and recuperation, both of which were purposely omitted from the furnace to simplify its construction for experimental purposes. It is stated that the success obtained would not have been possible without the use of heat-resisting steel in the construction of the furnace.

1 *Journal of the Iron and Steel Institute*, 1932, No. 1, p. 223.

## Some Experiments on the Resistance to Wear of Nitrogen-hardened Cast Iron

It has been shown that an aluminium-chromium alloy cast iron, when exposed to an atmosphere of ammonia gas under the conditions of the commercial nitrogen-hardening process, undergo a surface-hardening effect.[1] The most important applications of cast iron surface-hardened in this manner are those in which the conditions call for resistance to wear, and in this paper Mr. Hurst describes experiments arranged to study the behaviour of nitrogen-hardened cast iron under wear conditions, such as exist in internal-combustion engine cylinders. The experiments were made on a stationary test engine, and under road-test conditions. The results obtained are summarised in the following table :—

| Material. | Total Mileage. | Wear. Miles per 0·001 in. | Total Mileage. | Wear. Miles per 0·001 in. |
|---|---|---|---|---|
| *Stationary Engine Tests.* | | | | |
| Centrifugal cast iron, standard to B.S.I. Spec. 4K6 | 30,000 | 12,000 | — | — |
| Chromium alloy cast iron, centrifugally cast | 30,000 | 9,250 | 40,000 | 12,300 |
| Nitrogen-hardened cast iron | 30,000 | 24,000 | 40,000 | 32,000 |
| *Road Tests.* | | | | |
| Centrifugally-cast chromium cast iron, hardened and tempered | — | — | 40,000 | 4,520 |
| Centrifugally-cast nickel-chromium cast iron, hardened and tempered | 10,000 | 3,220 | — | — |
| Nitrogen-hardened cast iron | 10,000 | 19,020 | 40,000 | 10,100 |

A strict comparison of the results can be made only on the basis of equal mileages. At a mileage of 30,000 in the stationary-engine tests, a comparison can be made between nitrogen-hardened cast iron, standard centrifugally cast and chromium-alloy cast iron. At this mileage the ratio of the resistance to wear of nitrogen-hardened cast iron to standard centrifugally cast iron is as 2 : 1 and to chromium-alloy cast iron as 2·6 : 1. At a mileage of 40,000, the ratio of the nitrogen-hardened to the chromium-alloy cast iron still remains the same at 2·6 : 1.

In the tests under road conditions the wear value in miles per 0·001 in. of wear is smaller in magnitude than under the stationary-engine conditions, but at a mileage of 40,000 the ratio of the nitrogen-hardened to the hardened and tempered chromium-alloy cast iron is 2·2 : 1, a figure which is in close agreement with the stationary-engine tests. The ratio at 10,000 miles is much higher in favour of nitrogen-hardened cast iron, but in view of the comparatively short duration of this test the results are omitted from this summary.

These results demonstrate the improved resistance to wear under internal-combustion (petrol) engine cylinder conditions of cast iron surface-hardened by the nitrogen-hardening process. They also may be used to demonstrate the stability of the nitrogen-hardened surface under these same conditions.

## The Thermal Conductivity of Wrought Iron, Steel, Malleable Cast Iron, and Cast Iron

Various investigations carried out on the thermal conductivities of ferrous alloys have shown that the composition has an important influence on the heat-conducting property. In view of the high conductivity of ferrite and the low conductivity of cementite, it was considered of interest to determine the conductivities of a commercially pure iron, three hypo-eutectoid steels, a eutectoid steel, and a hyper-eutectoid steel. By doing so is was thought that a better approximation to the relative influence of the composition and structure would be obtained than from the previous determinations on grey cast iron, where such influences are complicated by the presence of graphite, phosphide eutectic, and sulphide inclusions. The testing of a whiteheart malleable iron, with a structure of pearlite and temper carbon, and of a blackheart malleable iron, consisting of ferrite and temper carbon, was also considered advisable, with a view to determining the influences of such structures and to

ascertaining if such irons gave results intermediate between those of steel and cast iron. These determinations have been made by Dr. J. W. Donaldson, and the results, given in this paper, show that the thermal conductivity of wrought iron is approximately 0·175 cal. per cm. per sec. at 100° C., a value slightly less than the value of 0·187 cal. per cm. per sec. previously determined for fairly pure iron. The values for the five steels at 100° C. decrease from 0·160 cal. per cm. per sec. for the 0·1% carbon steel to 0·117 cal. per cm. per sec. for the 1·09% carbon steel, while the blackheart malleable iron has a thermal conductivity value of 0·150 cal. per cm. per sec. at 100° C., and the whiteheart malleable iron a value of 0·115 cal. per cm. per sec. at a similar temperature. The five special cast irons have silicon contents varying from 1·87 to 6·50%, and show a decrease in thermal conductivity with increasing silicon. Thermal conductivity values are determined for all the alloys over a range of temperature from 80° to 450° C., and in every case a rise in temperature is accompanied by a decrease in the thermal conductivity.

## The Effect on Various Steels of Hydrogen at High Pressures and Temperatures

The development of many chemical processes, chiefly the synthesis of ammonia and the hydrogenation of coal and oil, involve the use of hydrogen at comparatively elevated temperatures and under high pressures, and, in order to determine the action of hydrogen on steels used in the construction of plants concerned in such processes, many investigations have been carried out. In the investigation which is the subject of this paper by Dr. N. P. Inglis and Mr. W. Andrews, a study has been in progress over a period of more than five years and it has yielded considerable data on the effect of hydrogen at a pressure of 200—250 atm. and at various temperatures between 150° C. and 500° C., on a number of steels.

The results of this investigation show that at high pressures hydrogen will attack steel at much lower temperatures than those causing attack at normal pressure. In the first stage of the attack the steel absorbs hydrogen, and this will cause embrittlement even though no decarburisation or disintegration has occurred. At this stage the steel can be restored to its original state of ductility by a suitable heat-treatment to drive off the hydrogen. In the later stages of attack the steel becomes decarburised and fissured, with consequent very severe loss in strength and ductility. The factors which determine the degree of attack are temperature, pressure, stress, composition of the steel, and its structure.

In any one steel the critical conditions giving rise to attack vary according to the structural condition of the steel—that is, according to the heat-treatment. For any one steel, the best structural condition is one in which the grain-size is small, and, in general, the hardened and tempered condition is recommended.

## Improving the Coking Performance of Weakly-Coking Coals

There are in Yorkshire, Derbyshire, Lancashire, North Staffordshire, and elsewhere, large reserves of coal of 83 to 81% carbon content which, when coked alone, may yield but a weak coke by the usual methods of coke manufacture. Efforts have been directed towards the improvement in coking performance of such coals, and this paper, by Mr. R. A. Mott and Dr. R. V. Wheeler, describes some work on the subject. As a result of the investigation the authors conclude that the quality of coke obtained from some weakly-swelling coals can often be considerably improved by adopting the practice of top-charging the ovens, instead of the more usual coke-charging, and by increasing slightly the rate of heating. If it is found that improvement in the quality of the coke can be effected in this way, a further improvement can be obtained by blending about 3% of fusain or coke dust with the charge.

Coals which cannot be coked successfully when top-charged, because they are too weakly-swelling, require the presence of a certain proportion, about 20 or 30%, of a strongly-swelling coal in the charge to enable them to yield a hard and non-abradable coke. The addition of about 3% of fusain or coke dust to such a blend is advantageous.

A method of treating weakly-swelling coals to improve the quality of the coke they yield, of which much is expected, is to incorporate about 3 or 4% of coke-oven tar with the charge. Such a treatment also has the advantage of enabling the coal to be stored without deterioration of its coking properties.

## Some Properties of Cold-Worked Sorbitic and Austenitic Alloy Steel Wire

This paper, by Mr. S. H. Rees, deals with the properties of cold-drawn chromium-molybdenum steel wire and with austenitic chromium-nickel steel in the cold-worked condition, with special reference to their behaviour under stress at raised temperatures. The chromium-molybdenum employed in the investigation was of the following composition :—

| C. % | Si. % | Mn. % | S. % | P. % | Ni. % | Cr. % | Mo. % |
|---|---|---|---|---|---|---|---|
| 0·34 | 0·18 | 0·54 | 0·03 | 0·03 | 0·07 | 1·1 | 0·27 |

It was found that the restoration of elasticity at atmospheric temperatures is complete after treatment at 250° C., but to secure elastic behaviour under stress at raised temperatures preliminary treatment at 400° C. is required. The loss of tension under stress at raised temperatures is much less in this wire than in carbon steel wire.

The austenitic chromium-nickel steel tested had the following composition :—

| C. % | Si. % | Mn. % | S. % | P. % | Ni. % | Cr. % | W. % |
|---|---|---|---|---|---|---|---|
| 0·15 | 0·27 | 0·19 | 0·030 | 0·035 | 9·9 | 16·1 | 1·0 |

The elastic properties at atmospheric temperature of the cold-rolled austenitic steel wire were restored to as high a figure as possible by reheating to 250° C., but treatment at 500° C. was necessary to secure the best behaviour of the wire under varying conditions of stress and temperature. A large increase in density occurred on reheating, reaching a maximum of 0·76% after treatment at 650° C. This was in part due to a reversion of $\alpha$ iron formed by cold-work to $\gamma$, and was accompanied by a decrease in length of 6·16%. In this decrease in length the austenitic steel wire differs from carbon steel and chromium-vanadium steel wires, both of which show an increase in length (with increase in density) after heating. The tendency to decrease in length probably assists in maintaining tension at raised temperatures. The relative loss of tension at temperatures of 200° to 300° C. of carbon, chromium-vanadium, chromium-molybdenum, and austenitic chromium-nickel steel wires has been determined in winding trials, the results of which are summarised in the following table.

| Type of Steel (wound at 36 to 46 tons per sq. in.). | Carbon. | Chromium-Vanadium. | Chromium-Molybdenum. | Austenitic Chromium-Nickel. |
|---|---|---|---|---|
| Temperature of initial treatment of the wire | 200° C. | 400° C. | 400° C. | 500° C. |
| Percentage loss of tension in the wire after heating at— | | | | |
| 200° C. | 21% | 10% | 6% | Nil |
| 250° C. | 42% | — | 14% | 3% |
| 300° C. | 58% | 24% | 20% | 10% |

## The Effects of Pickling on the Properties of Carbon Steels

The magnitude of the embrittling action produced in medium- and high-carbon steel wires on immersion in minerals acids of various concentrations and at different temperatures has been studied by Dr. Ian G. Slater, by means of a simple torsion test, and the results are given in this paper. It has been found that rapid embrittlement ensues immediately the wires are immersed in the acid, and that the rate of deterioration increases with the acid concentration and the temperature. Hard-drawn wire,

(*Continued on page* 158.)

# Shipping, Engineering, and Machinery Exhibition

*Some new features, information on which was not available for the advance particulars published in our last issue, are discussed.*

ORGANISED at the opportune time, when industry is showing signs of recovery, the exhibition at the Olympia is attracting more than usual interest. This is probably due to the fact that improved conditions has raised the prospects of many firms and led them to reconsider new installations, previously contemplated, which had been temporarily delayed, awaiting better conditions of trade to warrant the outlay involved. In view of the difficult time experienced there was never a greater need for a careful investigation along all avenues likely to lead to greater economy in production or improved quality of product, and the exhibits at Olympia are being closely scrutinised with these objects in view. In addition to a wide range of exhibits, advanced information on which was published in August METALLURGIA, several exhibits shown for the first time have attracted considerable attention. Amongst these may be mentioned new models of electric furnaces with forced-air circulation, and a new method of controlling electric-induction furnaces; several new testing machines and appliances have also made considerable impression on visitors.

The tool-room temperating furnace, exhibited by Wild-Barfield Electric Furnaces, Ltd., is a new model of electric furnace with forced-air circulation. It embodies all the salient features of the full production furnace of this type, but is designed primarily for tool-room use, where large production is not required. The actual chamber is 18 in. diameter by 18 in. deep, with an inner container 11 in. diameter and 11 in. deep. This inner container is made of refractory material, with continuous grooves on the exterior surface, in which a heating element of highest grade nickel-chromium is wound. It thus serves the purpose of a support for the element and baffle to prevent direct radiation on the work.

The annular space between this refractory liner and the insulated wall of the chamber provides passage for the air, which, during its upward travel, receives heat from the elements, and during its return travel through the chamber imparts this heat to the charge in the work-basket, which measures 10 in. diameter by 10 in. deep. The furnace is designed for temperatures up to 650° C.; it therefore covers all tempering requirements for the tool-room, including carbon and alloy steels, and secondary hardening of high-speed steel.

A new model of this type of furnace is also exhibited by Birmingham Electric Furnaces, Ltd., as representative of this firm's junior series. As in the previous instances it is made in two forms, one being suitable for temperatures up to 400° C., and the other up to 650° C. The construction of the furnace itself is identical for either range, and the design of the temperature regulator forms the only difference between the two.

It will be appreciated that refinements such as the charge-progress order, which is fitted to the larger production furnaces of this type, are not included in the specifications of these new models. For tool-room use, however, they mark a definite advance in technique, making available a very high degree of accuracy in the treatment of delicate tools, etc. In both instances the equipment has been designed with a view to the utmost simplicity both in installation and operation, and in keeping with the requirements for economy.

Electric Furnace Co., Ltd., and Electric Resistance Furnace Co., Ltd., are exhibiting an interesting new method of controlling electric-induction furnaces. A self-regulating induction furnace for heat-treatment and low-temperature metal melting has now been developed for direct connection to ordinary low-tension mains. A physical constant is used for temperature control, so that no variation of temperature can occur accidentally, and no failure of control equipment can result in spoilt work.

The temperature is controlled by the insertion of special alloy self-regulating bars, which can be supplied for controlling the furnace at any temperature between 400° C. and

*New junior electric heat-treatment furnace with forced-air circulation.*

1,000° C. These bars lose their magnetism at the required temperature, and the input of energy into the furnace is immediately diminished until the bars regain their magnetism and the load is automatically increased. Thus the control is dependent on this physical constant which is absolutely unchangeable for a given alloy.

The furnaces already developed technically and commercially are of four types, and include baffle furnaces, for general heat-treatment purposes; low-temperature melting furnaces for aluminium, lead, type metal, etc.; balanced furnaces, for precision heat-treatment of press tools, etc.; and continuous-heating furnaces for small articles such as bolts, links, gudgeon pins, and also continuous-strip annealing equipment.

The principle on which the construction of all these

furnaces is based is shown in the accompanying diagram in which (A) is a primary copper winding connected to any ordinary low-tension alternating current supply; (B) is a magnetic core which may itself constitute the furnace muffle, or which may be inserted into the muffle in the form of bars. It is made of one of a series of alloys of the reversible magnetic type, which lose and regain their magnetism at approximately the same temperature. It is closely surrounded by a closed cylinder (C), which is substantially non-magnetic at the working temperature of the furnace. $B^1$ is a laminated iron core, which with (B) completes the magnetic circuit of the furnace. (D) is a heat-insulating lining to reduce door losses, and (E) is the heat-insulating lining of the furnace.

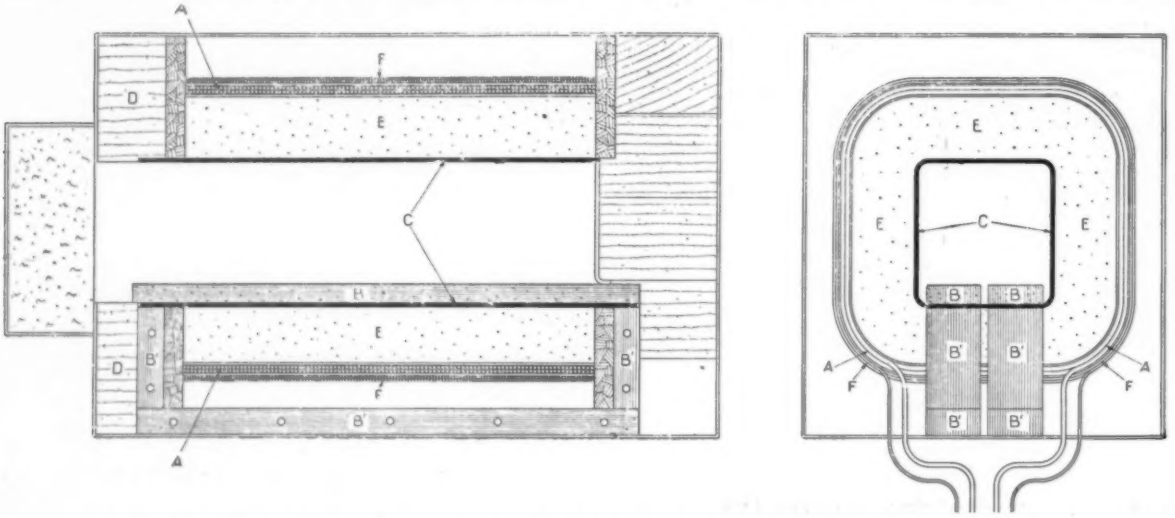
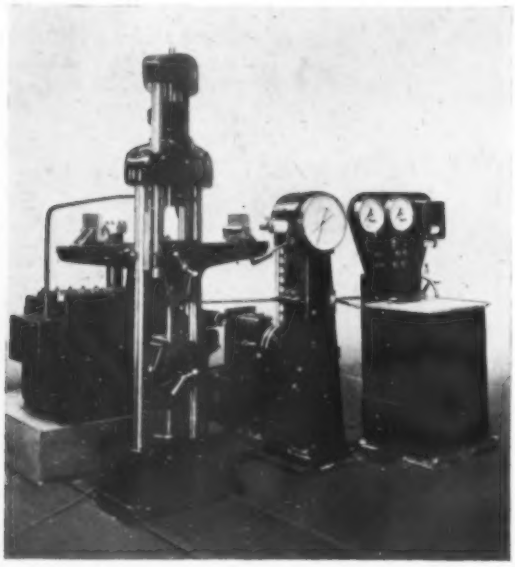



*Diagram showing the principle of construction of the new method of controlling electric induction furnaces.*

When current flows through the coil (A) the latter acts as the primary of a transformer, of which the cylinder (C) is the short-circuited secondary and (B) and $B^1$ the core. Current is induced in the cylinder (C), which becomes heated in consequence. This heat passes by conduction to (B), which ultimately reaches such a temperature that it loses its magnetism. This reduces the flux through the core to such an extent that not enough heat is generated in the cylinder (C) to compensate for the losses by radiation, etc. The temperature of (B) accordingly falls until it reaches the point when it regains its magnetism. The induced current then increases and the temperature of the cylinder (C) again begins to rise. The small amount of heat generated in (B) by eddy currents is not sufficient to interfere with the cycle described above. In some cases an additional copper coil (F) is provided to which a condenser may be connected for power-factor improvement, but in general this is found unnecessary.



*Universal testing machine for endurance alternating loads.*

The material forming the ferro-magnetic muffle or bars has been the subject of careful research, and a wide range of different alloys has been selected. As there is only a small difference of temperature between the points at which the ferro-magnetic material loses and regains its magnetism, the control of temperature is very close. This is a development of considerable significance; it provides a system of heating which is certainly ingenious, and one which seems likely to find wide application for small furnaces of varying kinds. Judging by the interest displayed in this method of controlling induction furnaces at Olympia its application should rapidly increase.

It is gradually being recognised that the vibratory strength of a material provides a very reliable guide to its suitability for structural work, and the universal vibratory testing machine for endurance alternating loads of the "Losenhausen" type, exhibited by the Selson Machine Tool Co., Ltd., has been the subject of much interest. Tensile, compression, and transverse tests under alternating stress can be performed on this machine; in addition to the application of alternating loads, any required preliminary static load can be applied to the specimen. This makes it possible to reproduce any vibratory stress to which the material is subjected under service conditions. It is of interest to note that all the tests, for which the machine is designed, are very easily performed.

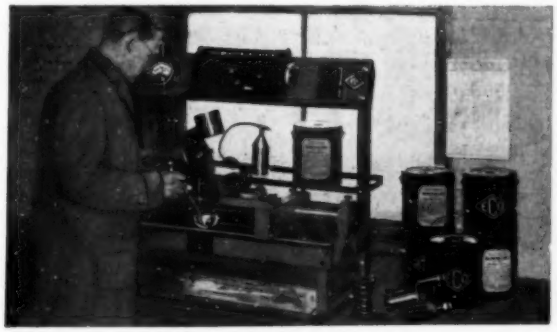
The machine, which is fitted with hydraulic drive, is shown in the accompanying illustration. It has a standard at one side which contains the reading device and the arrangement for producing the pressure. A box-casting contains the alternating stress mechanism, while the pressure-indicating mechanism, as well as the autographic recorders for alternating stress, together with the necessary operating switches, are accommodated at a special switch desk. A special pump serves, in connection with vibratory endurance tests, for applying preliminary static loads.

A wide range of electrical and mechanical measuring, testing, indicating, and recording apparatus is exhibited by Elliott Bros. (London), Ltd.; some of the items included are exhibited for the first time and represent this firm's latest and most important apparatus. Of these, attention is particularly directed to Siemen's programme transmitter.

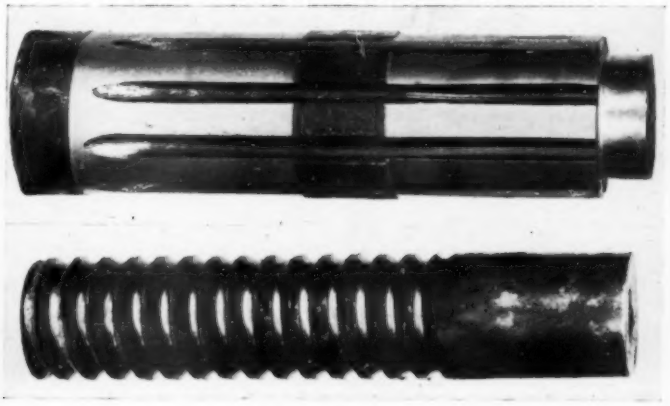
This instrument is used in conjunction with an automatic

regulator, and enables a definite and predetermined programme of operation to be followed, for certain manufacturing processes; for example, when it is required that the temperature of a furnace shall first rise then remain constant for a definite period, and, finally, drop again at the end of the process. This method of following a predetermined programme of operation has been successfully applied for the control of annealing and carburising furnaces in the steel industry; for drying and firing ceramics and porcelains; for the treatment of cellulose in celluloid and paper mills; and for the control of vulcanisation in the preparation of rubber. The programme transmitter incorporates a number of cams, which are cut in accordance with the required programmes, and driven by means of a clock or an a.c. synchronous clock-motor. The operation of the cam causes a "ring tube" resistance to be varied, applying a back E.M.F. to the automatic regulator, complementary to the E.M.F. which is being measured, the sum of the two being kept constant corresponding to the position on the indicating scale at which the control is set.

Another instrument shown on this stand is the Siemen's cross-filament optical pyrometer. This is a new type of optical pyrometer, which is direct reading and completely self-contained in a small portable case.



*Using an electromagnetic crack detector.*



*Oxygen grooving applications—cutter controlled by machine.*

The principle involved is that of maintaining the filament of an electric lamp at a definite known and constant temperature, and reducing the incoming radiation from the hot body whose temperature is to be measured until the filament apparently disappears into the background. This reduction of the radiation is accomplished by the interposition of a wedge-shaped graduated absorption screen (calibrated in temperature degrees) between the standard lamp and the hot body. A unique feature of this pyrometer is the ingenious method of obtaining and maintaining the standard lamp temperature. Actually, the lamp has two filaments crossing each other, a ribbon and a wire flattened at the place of conjunction. These filaments are composed of two materials which have diverse temperature-current characteristics. They are connected in series and supplied with current from an incorporated battery through an adjustable resistance. The two filaments are equally brilliant at one temperature only, and this temperature is quickly and easily obtained by adjusting the resistances until the two filaments merge into each other. This adjustment needs very little attention, once it has been set, unless the battery is becoming exhausted. For short-duration readings the incorporated battery is sufficient, but for longer tests a plug and socket is provided for an external accumulator. Both the cross filaments and the observed object can be sharply focused by adjusting the position of the lenses. Two ranges are available, viz., 800°—1,500° C., 900°—1,800° C. As no part of the instrument is in actual contact with the furnace deterioration is eliminated.

A remarkably simple and effective device for indicating the level of the contents of a bin or bunker in which powdered or granular substance is stored is provided by the "Tollemache" bin level indicator, manufactured by Elliott Bros. The instrument, which is the only one of its kind, has been primarily designed for use with pulverised fuel, but can be satisfactorily operated with practically any pulverised or granular substance.

The universal demand for reduction in weight and the employment of high-tensile steels of small section used under higher working strains has led to considerable concern regarding the approach of fatigue and wear of parts which might lead to serious consequences. Under such circumstances reliable inspection is difficult, and many methods have been suggested to facilitate systematic inspection. An apparatus, known as an electromagnetic crack detector, exhibited by Equipment and Engineering Co., Ltd., offers a reliable method. It is based on the electromagnetic principle. Briefly, it necessitates highly magnetising the part to be tested by means of a powerful electromagnet of special design, the two pole pieces of which are so shaped and disposed that the test-piece laid across them completes a closed magnetic circuit of low reluctance. A crack in the test-piece breaks the lines or force, causing them to emerge on the surface of the iron or steel, and form north and south magnetic poles. A special detecting ink applied detects any crack in the presence of the magnetic field. This is a very ingenious method, and one claimed to be absolutely reliable.

It is of interest to note that the British Oxygen Co., Ltd., because of limitations of space for their exhibits, found it necessary to transfer to a larger accommodation. The practical application of this company's oxy-acetylene equipment has attracted many visitors, and the examples of accuracy in cutting by this method, which are illustrated, give an indication of the control possible. Demonstrations in gas and electric arc welding show the progress made in this operation.

During recent years the bend test has become increasingly popular in connection with the testing of weld metal, by because it is recognised that it constitutes a rapid and inexpensive method of determining the ductility of a weld joint. A hand-bend testing machine is shown in operation by Murex Welding Processes, Ltd., on which demonstrations are given. The object of this machine is to provide a simple, inexpensive, and quick method of carrying out a bend test as a measure of ductility of weld metal and welded joints.

The exhibit of the Calorizing Corporation of Great Britain, Ltd., comprising a small section of roof hanger assembly for oil-cracking stills, in which the tubes are supported by means of hangers from the roof, the tubes being of weldless steel protected by the calorizing process, and the hangers in "Calmet," a high temperature resistance alloy. Further, heat-treatment containers for case-hardening, annealing, cyanide and lead-hardening, both in calorized pressed steel construction, and also in "Calmet," together with calorized weldless solid drawn steel pyrometer sheaths as used in conjunction with pyrometers, proved of considerable interest.

# Reviews of Current Literature.

## Fire Assaying

ORIGINALLY published in 1922, a second edition of this useful text-book has recently been produced. The book is the outcome of a set of mimeograph notes, prepared and intended for use in the course of fire assaying at the Massachusetts Institute of Technology. Although it is intended primarily as a college text-book, every effort has been made to give the underlying scientific reasons for the many phenomena which occur, as well as the rationale of each process and detail of manipulation. The author considers that the object of instruction in fire assaying should not be merely the training of students to obtain results of a certain degree of precision by blindly following some set procedure, as is, unfortunately, too often the case in this and many other studies. The attention of students should, of course, be focussed on the physical and chemical principles which govern the various operations. Obviously, if they thoroughly understand the reasons for the use of each of the reagents, and for the various details of technique, they will experience little difficulty in dealing with an ore of unfamiliar constitution, and will readily make up their own assay charges and outline the details of manipulation.

There is much to be said for the author's belief that a course in fire assaying should introduce the study of metallurgy because the study of general metallurgy is made more interesting if the various processes of the quantitative determination of metals in ores and metallurgical products, by means of heat and dry reagents, are used to illustrate principles. Most of the principles of metallurgy are used in one stage or another of the fire assay, and if instruction is given in this connection it awakens most interest. Opinion differs, however, on what constitutes the most profitable form in which instruction in metallurgy is presented ; the field is large and comprehensive, and time is an important factor.

The instruction given in this book is admirably arranged. Explicit directions are for the first analysis given in such a way that they not only save the students' time, but make it possible for him to attack the subject intelligently and without unnecessary delay. Less stress is laid upon detailed precedure as the work progresses and the student is placed more and more upon his own resources, which tends to encourage him to work out his own assay charges from his knowledge of fundamental principles, aided by a study of typical examples which are given.

The arrangement of the laboratory work begins with cupellation, first in the qualitative, and then in the quantitative way. The assay of lead bullion leads naturally to parting for the determination of the gold, after which either scorification or crucible assaying may be undertaken. This text-book covers a wide field in a very lucid and instructive manner. It is complete with a useful index, and is a credit to the publishers as well as the author.

By EDWARD E. BUGBEE, published by Chapman and Hall, Ltd., Henrietta Street, Covent Garden, London, W.C. 2, price 18s. 6d. net.

## The Alloys of Iron and Silicon

THIS book, which has just been published, is the second alloy of iron research monograph prepared under the direction of the Engineering Foundation. Like the first of the series, which deals with the alloys of iron and molybdenum, this book puts at the disposal of the investigator, as well as practical men, the available information on the alloys of iron and silicon. It assembles useful data on the subject, and provides critical summaries of original work done on these alloys that simplifies further investigations and gives valuable information with little loss of time.

The manufacture properties and uses of iron and steel containing silicon as an alloying element are summarised in such a way as to be helpful to engineers, metallurgists, steelmakers, and foundrymen ; while important on data such materials as silicon alloy structural steels, silicon-manganese spring steels, silicon electric sheet, and acid-resisting cast irons are also concisely summarised.

All previous investigations on the binary iron-silicon alloys, the tenary iron-silicon-carbon alloys, and the more complex systems are reviewed ; following which is a summary of the system and new phase diagrams of the binary and ternary systems. Conflicts in data are noted and attention directed to existing gaps in the various systems, so that the need for further research is rendered more apparent.

Written by Earl S. Greiner, J. S. Marsh, and Bradley Stoughton, it is offered to members of technical societies, metallurgists, engineers, and others in the iron and steel industry at $4·00, providing the order is received by the publishers before October 10, 1933. The first volume of the series, viz., "The Alloys of Iron and Molybdenum," is available at $5·00 if ordered in conjunction with the second of the series. Orders should be sent to McGraw-Hill Book Co., Inc., 330, West 42nd Street, New York, U.S.A.

## Practical Microscopical Metallography

MUCH development has been effected since Sorby made the first systematic attempt to discover, by the aid of the microscope, the distinguishing structural characteristics of different samples of iron and steel. Sorby's work was taken up by many other investigators, and to-day metallography, in addition to the microscopical examination of metals, embraces all methods employed in the study of the constitution and internal structure of metals and their alloys, and the influence of structure and constitution on the physical and mechanical properties.

It is recognised that the structure of a metal or alloy alone will not give full information regarding its origin or the relation of one constituent to another, hence the microscope is supplemented by other instruments of research. Thus the equilibrium diagram represents condensed information from the results of thermal and microscopical examination in conjunction with chemical analysis. Other methods have been used to confirm and extend these results. Obviously, therefore, metallography is a very comprehensive science, a full exposition of which would be difficult to encompass.

In this work, however, the structure of metals and alloys of industrial importance are considered in the light of their constitution, but with special reference to their mechanical properties and practical utility. A set of typical photomicrographs is given, suitably annotated and accompanied by a concise account of the results of metallographic researches and other investigations that afford an interpretation of the structures observed in commercial materials and illustrated in the photomicrographs. A description is given of the practice of microscopical examination and photomicrography, as also are methods of overcoming difficulties which may be encountered.

It is a second edition and the authors have taken the opportunity to enlarge several sections, especially those dealing with photomicrographic technique, the structure and constitution of alloys, alloy steels, the micrographic examination of steel and of copper alloys, etc., and to add a new chapter dealing with low-power photomicrography and macrography.

The book is well written and prepared, and cannot fail to be of great value to metallurgical students and students of engineering ; while metallurgists, engineers, and other users of metals who desire to familiarise themselves with this method of examination will find it a reliable treatise.

By R. H. GREAVES, D.Sc., and H. WRIGHTON, B.Met., published by Chapman and Hall, Ltd., Henrietta Street, London, W.C. 2, price 18/- net.

# Bending and Hardening Machine for Laminated Springs

SEVERAL developments have been made during recent years in the machinery employed in the manufacture of springs and also for reconditioning springs that have lost their shape in service. An interesting machine in this category is a bending and hardening machine designed for large, laminated springs, common to rolling stock, Many special features have been incorporated in this machine which make it of special value in the manufacture of new springs and the reconditioning of old ones. Probably the most important of these features is an adjustable gripping device for the heated springs, which can be set to any radius within the limits customary for laminated springs, a flexible gripping strap, composed of a number of laminated springs, and the provision of two sets of gripping appliances for the purpose of enabling a newly heated spring to be inserted while another spring is being quenched.

As will be noted in Fig. 1, the gripping device consists of two templets, composed of laminated springs, which accommodate themselves to any required radius. These two templets are part of a rotating system which is balanced in such a way that the templets and the heated leaf are automatically closed, plunged into the tank, reopened and brought out again, without any hand operation. The

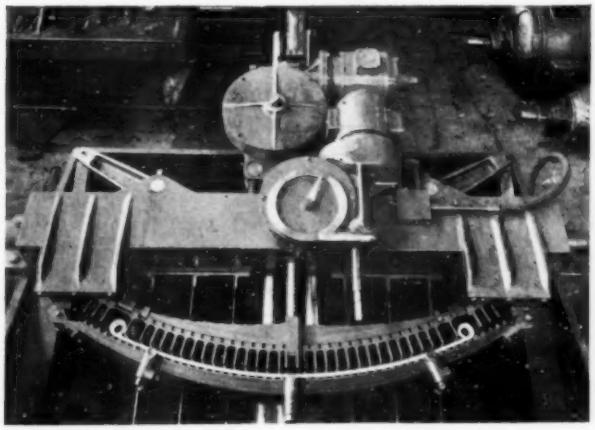


*Fig. 1.—Single automatic laminated spring bending and hardening machine.*

bending templet is designed as a triangular laminated spring to obtain a true arc of circle at any desired radius. Thus any pressure applied in the centre will always cause the outer leaf to assume the arc of a true circle. The desired radius of curvature is set by means of an electric motor, and can be read on a dial control of bending changes being effected by push-button switches. The base carries a row of pressure fingers, or teeth, which are flexibly supported against each other, and can be shifted to make room, if necessary, for eyes at the ends of springs to be hardened. The gripping strap is so designed that there is no possibility of the spring warping or getting out of shape during quenching.

When the heated leaf is placed on the teeth of the bending strap the bending motor is started by means of a push-button, and the gripping strap is drawn together, holding the leaf firmly. The pressure exerted by the gripping strap is adjusted to suit the resistance of the spring. As soon as the required pressure is attained the bending motor is switched off and the turning motor started into operation. This motor automatically turns the system of gripping templets through an angle of 180°, which places the spring, together with the fixture by which it is held, into the quenching bath, the temperature of which is kept constant by means of a thermostat. After the quenching process is finished the fixture is returned to the horizontal and the hardened spring released, when the machine is ready for the next heated leaf. The output of this machine is approximately 50 to 55 springs per hour.

Operating on an exactly similar principle a modification of this design is shown in Fig. 2. This is a double automatic bending and hardening machine for similar types of springs. It has been designed with two sets of templets, both of which are part of the rotating system, and are so arranged that one set is submerged in the quenching tank when the other is ready for loading with the heated leaf. With this machine, after completion of the 180° turn, the second gripping fixture is on top, open, and ready to receive a new heated spring. When the quenching time for which the machine has been set is over, this new spring is placed into the bath by another half-turn of the machine. A pointer moving slowly over a dial during the quenching enables the workman to tell exactly when he must place a fresh red-hot spring into the fixture. After the quenching process has been finished the hardened spring automatically drops on a discharge chute, whence an endless conveyer chain takes it to the tempering furnace.

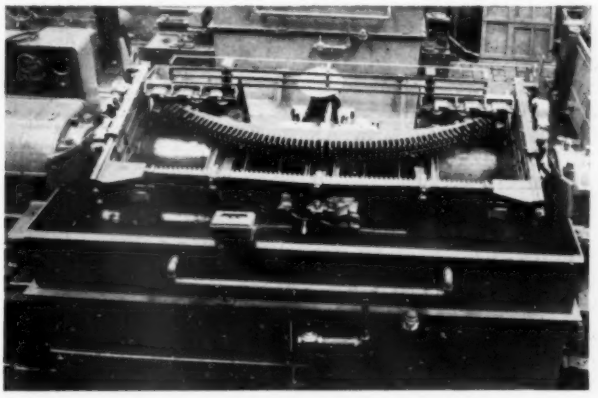


*Fig. 2.—Double automatic laminated spring bending and hardening machine.*

It is a special feature of this machine that by a turn of a knob it can be made to work fully automatically, so that the output is not influenced by the attendant. The duration of the working period, which is determined by the quenching time, can be adjusted as required. The output of the machine shown in Fig. 2 is approximately 100 springs per hour. These machines, which are designed and built by Collet and Engelhard, Offenbach-main, Germany, are working successfully in several large spring-reconditioning plants of Europe, and are in continuous service.

It is of interest to note that every effort is made to maintain the quenching medium in suitable condition; compressed air is forced automatically through it during the hardening time, which facilitates the thorough circulation of the liquid and removes the steam bubbles from the leaf being hardened. In order that the temperature can be regulated automatically an expanding member in the quenching medium acts, by means of hydraulic transmission, on a relief valve in such a way as to increase the flow with rising temperature in the tank, and to restrict the flow with falling temperature of the quenching liquid. The desired temperature is adjustable. These machines are available in several sizes to suit the different maximum lengths of springs; these range between 52 in. and 105 in.

## The Soviet Manganese Industry

BEFORE the World War manganese was produced in Russia in Chiaturi (Georgia) and in the Nikopolsk region of the Ukraine. Practically the whole output was exported, only a negligible quantity being consumed at home. During the war production declined considerably, and stopped altogether in 1916, and it was only after the establishment of a Soviet Government in Georgia that the manganese industry of Chiaturi began to revive again. After the termination of the Harriman concession the Chiaturi mines passed into the management of a State trust, known as "Chiatur-Marganets," when a rapid growth in the production of manganese commenced. By 1929 the output, in comparison with the previous year, had trebled, and increased still more in succeeding years.

The total output of manganese in the Soviet Union in 1928-29 was almost double that of pre-war times. There was a marked increase in the consumption of manganese in the country and in the quantities exported. In 1931 of the total world export of manganese the proportion coming from the U.S.S.R. was 52·3%, while the home consumption in the same year had risen to 32·2% of the total output.

The enterprises of "Chiatur-Marganets," the Chiaturi Manganese Trust, are at present undergoing a radical reconstruction. This year a sum of 25 million roubles is being expended on the rationalising of production—the centralisation into bigger units of production, the mechanisation of mining and other processes. The number of units (which are at present 14) are to be centralised and reduced to seven, which will effect a considerable economy in production. Experiments have been made for the first time in the use of cutting machines in the raising of manganese ore, with satisfactory results. The reconstruction plans also include the centralisation of enriching works. A big enriching works with an annual capacity of 900,000 tons of raw ore is to be built. In regard to the reconstruction of the Chiaturi enterprises it is expected to increase the output capacity of the mines, and next year the anticipated output of manganese is twice as great as that planned for the present year.

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## Investigation of the Nitriding Process

W. LIESTMANN has studied the reactions taking place between the gas phase and the surface of the steel, as well as the immigration of the nitrogen into the steel by gas analysis, microscopic examination, and depth-hardness curves. The experiments were carried out at 500° C., using a mild iron and a nitriding steel containing carbon, 0·25%; aluminium, 1·1%; and chromium, 1·4%, both in the normalised and the quenched and tempered condition. Preliminary experiments made with iron in powder form showed that at a constant rate of flow a state of equilibrium is reached in that the nitrided iron decomposes a constant quantity of ammonia gas by catalytic action. By varying the rate of flow the nitrogen content of the solid phase varies together with the quantity of gas decomposed per unit of time. With mild iron and nitriding steel a state of equilibrium between the gas phase and the surface of the steel is not reached, the quantity of gas decomposed increasing with the decreasing rate of immigration of the nitrogen. With nitriding steel the quantity of gas decomposed is by 50% to 60% less than with mild iron. The reaction layer on the surface is in correlation with the gas phase and the starting-point of the nitrogen immigration, the active part being the nitrides of iron. The stable nitrides of aluminium and chromium are not able to advance the immigration by taking up and giving off nitrogen. With mild iron the reaction layer on the surface consists of two zones, the $\epsilon$ and $\gamma$ phase, the immigration starting from the latter by true diffusion and nitration of the layers between the grain boundaries which easily form nitrides. With nitriding steel the reaction layer consists only of $\epsilon$ crystals. Nitrogen immigration takes place by reactions at the nitriding temperature along the grain boundaries and by the formation of acicular lamellæ. Fine segregates caused by true diffusion with subsequent coagulation at the nitriding temperature are only found after long nitriding times in the innermost layer of the normalised steel. The nitriding process cannot be speeded up by additional substances brought in the nitriding chamber. Once the reaction layer on the surface has formed, and provided that the phase richest in nitrogen is always available, the nitrogen immigration is only dependent on the decomposition rate of the iron nitride and the composition and the structure of the steel. It is, however, possible to reduce the catalytic decomposition of the ammonia gas without impairing the nitrogen immigration, by packing the steel in silica gel, or pure or soaked with calcium chloride. (Archiv für das Eisenhüttenwesen, Aug., 1933.)

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# Catalogues and Other Publications.

The Broughton Copper Co., Ltd., Manchester, have recently published a booklet covering their activities at Widnes and Liverpool. It gives comprehensive information regarding their products, but the major part of the book is concerned with technical data and specifications. It is excellently produced, well illustrated, and with a useful index occupies 92 pages. Users of copper will find this booklet of considerable value.

The latest issue of *Sands, Clays, and Minerals*, published by A. L. Curtis, Chatteris, England, is comparable with any of the previous issues. It is well prepared and contains some interesting articles, notably: Fluorspar in Industry," "Canada's Mineral Wealth," "Treatment of Platinum-Iridium Scrap," "Gypsum—Origin and Uses," and several others that are informative, including notes on sand analysis. The issue contains many illustrations which are well produced.

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## The Iron and Steel Institute Sheffield Meeting

(*Continued from page* 152.)

particularly in the large gauges, is extremely susceptible to the embrittling effects. Deterioration proceeds at a less rapid rate when an inhibitor such as flour or yeast is added to the pickle. A mixture of flour paste and stannous chloride solution has been found to be particularly effective in this respect.

Notched-bar impact tests on a series of plain carbon steels indicated the surprising result that in several instances the steel had become toughened to a marked degree after chemical pickling in sulphuric acid or electrolytically as cathode. The maximum increase in the notched-bar impact value was found to be from 30 to 60% in several of these steels. Some of the steels showed embrittlement after similar treatment; the change in impact value depends both upon the time of pickling and upon some characteristic in each sample of steel which is yet to be defined. Recovery of toughened and embrittled specimens takes place on exposure in the laboratory atmosphere or more rapidly on immersion in boiling water.

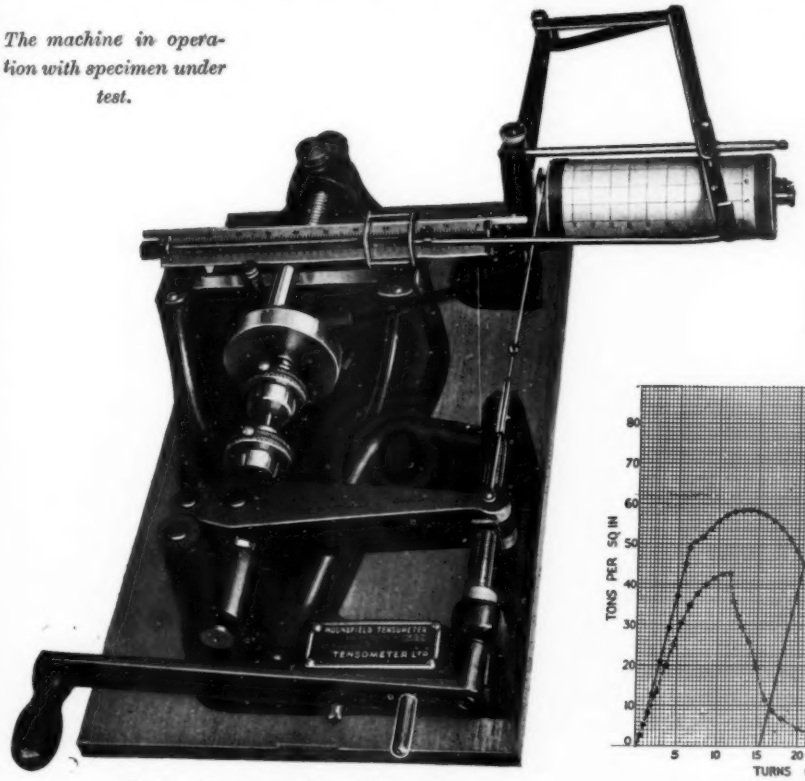
Tensile tests showed that the properties of steels of the higher carbon contents undergo the greatest modification after pickling; the percentage reduction of area is particularly reduced and there is a decrease in the percentage elongation. A slight increase in the tensile strength was noted in all pickled specimens.

Hardness determinations, using the Brinell method, showed a slight increase in the Brinell hardness after electrolytic pickling. When examined by an impact hardness test, all samples after treatment were found to be definitely softer. Recovery of the original hardness took place after suitable exposure.

# Recent Developments in Tools and Equipment

## A PORTABLE TESTING MACHINE

THE rapid development of both ferrous and non-ferrous alloys has given the engineer a wide range of materials from which to make a choice in selecting those that most adequately meet the requirements for any specific duty. The majority of these alloys are supplied to specifications which to a certain extent determine their fitness for any particular job. The properties of many alloys however, are so dependent upon their heat-treatment that it is almost invariably necessary to determine them from a test-piece which has had precisely the same heat-treatment as the finished article. The regular application for an ever-increasing number of alloys has also necessitated greater care in determining the stresses to which the various parts of a mechanism are likely to be subjected, and testing during various processes of manufacture is being increasingly recognised as essential.




*The machine in operation with specimen under test.*

*Fig. 1.—Testing machine with recorder.*

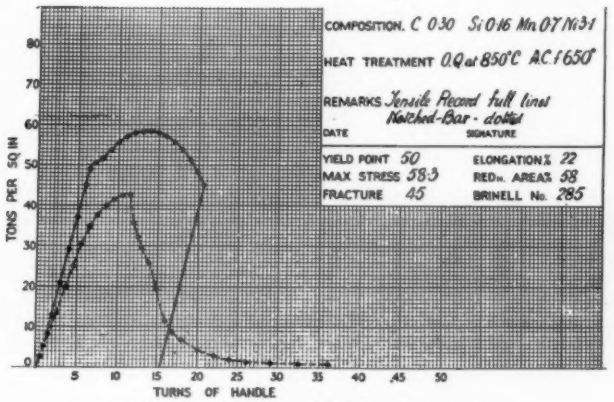

COMPOSITION. C 0·30 Si 0·16 Mn 0·7 Ni 3·1
HEAT TREATMENT OQ at 850°C AC 650°
REMARKS Tensile Record full lines Notched-Bar - dotted
DATE SIGNATURE
YIELD POINT 50
MAX STRESS 58·3
FRACTURE 45
ELONGATION% 22
RED. AREA% 58
BRINELL No. 285
TONS PER SQ IN
0 10 20 30 40 50 60 70 80
5 10 15 20 25 30 35 40 45 50
TURNS OF HANDLE

*Fig. 2.—Showing notched-bar test graph.*

Opinions differ as to what constitutes the most adequate test. Much, of course, depends upon the conditions under which the particular part is to be used, but the physical properties determined by tensile tests, hardness tests, and bending tests are generally recognised as suitable for general testing of ferrous and non-ferrous materials. There are many machines available that can be relied upon to give very accurate values of these properties, but not all of them are convenient for normal every day operations in the shops or in the workshop laboratory. For many such duties the size of many existing machines is a distinct disadvantage to their use, and efforts have been made to design smaller, portable machines that would fulfil the requirements of modern production methods in the workshop. Considerable success in this direction has been achieved. Not the least successful of these is the "Hounsfield Tensometer," developed comparatively recently after much experimental work. This apparatus has been applied under normal workshop conditions in a wide variety of works, and the results obtained are such that machines of this design are being regularly employed as a means of safeguarding the quality of products. There are several features about this apparatus that are of special interest, and we know of no other apparatus that is so complete a testing equipment in itself. Something of its range and convenience will be realised when it is stated that not only are the five chief results of a tensile test—viz., yield-point, ultimate stress, stress at fracture, percentage elongation, and percentage reduction in area—all read off a graph or a gauge without calculation, but the following tests can also be carried out with the same machine—viz., Brinell hardness test, notched-bar test, bend test for brittle metals (*e.g.*, cast iron), strip test for sheet material.

A remarkable feature about this machine is its lightness—it weighs only 36 lb., yet it is capable of testing the properties of metals up to 200 tons tensile strength. Designed for production testing, the machine is essentially practical, despite its size. One of its advantages is undoubtedly the smallness of the test-pieces employed; these have a cross-section varying from $\frac{1}{100}$ to $\frac{1}{7}$ of a sq. in., and a range of eight sizes of specimen test-pieces are suggested as suitable for ferrous and non-ferrous metals, and also for non-metallic plastic materials. In its latest form this machine is produced complete in a portable case with an autographic recorder, capable of accommodating a full range of test-pieces, with at least two sets of chucks to deal with four of the test-pieces recommended, universal elongation per cent., and reduction in area gauges capable of dealing with the whole range of test-pieces, and one set of notched-bar apparatus; additional equipment is also available for carrying out bend tests on cast iron and strip tests.

The use of small test-pieces in addition to reducing the cost in preparing them, enable these to be cut direct from a forging or casting, and thus ensure greater accuracy than would be obtained from test-pieces prepared separately. For example, test-pieces can be cut from thin webs of castings or stampings, or from plates before and after being pressed into frames or rolled in various shapes. A

transverse test-piece can be cut from a rail as easily as a longitudinal test-piece. Obviously, if an uncertainty arises regarding the soundness of a casting or a stamping at any point, a test-piece can be taken from that point for trial before quantity production begins. Similarly, a test-piece taken from the material adjoining a fracture will generally supply information from which the cause of fracture may be diagnosed.

The main features of this machine will be observed in the illustration, Fig. 1, in which a specimen is being subjected to a tensile test. The test-piece is held between the chucks, and by turning the handle a lever is operated which applies a load to one end of the test-piece while the other end transfers the load to the centre of a spring beam. The deflection of the spring is proportional to the load, and by being transmitted to a piston in a cylinder of mercury, it is magnified and shown by the travel of the mercury in a thermometer tube alongside a graduated scale.

The autographic record is taken on a special sheet of squared paper mounted on a drum whose axis is parallel to this mercury column, being pricked by a needle when this is pressed in a carriage which is pulled along the top of the drum by a cursor caused by hand to follow the end of the mercury column. The drum is turned beneath the needle through an angle proportional to the turns of the handle, moving the paper at right-angles to the path of the needle. Where a permanent record is not required, and the yield-point and ultimate tensile strength are clearly defined by the movement of the mercury column, the stress-strain diagram need not be plotted. By means of the universal gauge, the elongation percentage is determined without any calculation, while an adjustable reduction in area gauge also gives a direct reading. A typical permanent record from this machine is reproduced in Fig. 2. Other tests mentioned can be carried out with confidence, and by very simple means.

Tests have been conducted with this machine by independent authorities, and a comparison made with results obtained on larger machines. The differences have been well within those to be expected between two tests of one material on one machine. Thus, this very small machine covers a remarkable range of tests, and gives accurate results, yet its initial cost is relatively low, the test-pieces used are inexpensive to prepare and the machine is easily carried from place to place. The striking success which the machine has already had in the short time since its introduction is probably largely due to the appreciation of its autographic records for showing the properties of the material at a glance. It is supplied by Tensometer, Ltd., 73, Southampton Row, London, W.C. 1, and is being shown at the Shipping, Engineering and Machinery Exhibition.

## THE PYROPTIC INSPECTION WINDOW

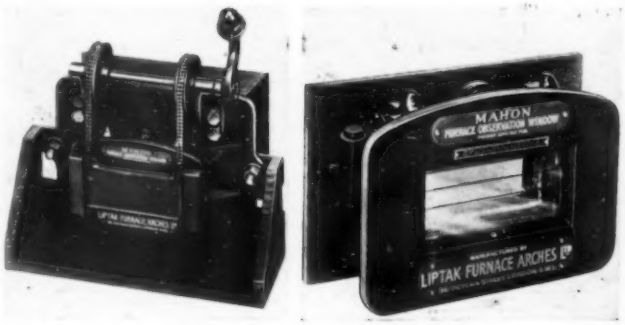
IT is not necessary to emphasise that a regular inspection of the interior of furnaces of all kinds in the metallurgical industries is of great assistance in obtaining efficient results as regards combustion and heat-treatment. Important also is that any deterioration of the brickwork, or other part of the equipment, can be detected immediately.

The observation of furnaces cannot, of course, be carried out with the naked eye, because of the blinding effect, and to wear special coloured glasses, or carry a piece of smoked glass, is a crude and troublesome proceeding which means, in practice, that observations are soon abandoned.

In this connection, however, Liptak Furnace Arches, Ltd., of London (38, Victoria Street, S.W. 1), supply neat and efficient "Pyroptic" inspection windows (H.G.B. Mahon patent). These are fitted permanently in any part of the setting, either the doors or walls, and consist of a metal framework carrying a comparatively large area of tinted glass, through which a complete view of the interior of the furnace is obtained in comfort.

The main problems concerned with the efficient design of windows of this kind are to prevent the glass cracking by the high temperature, as well as rapid changes of temperature, and also to ensure reasonable freedom from mechanical breakage and clearness for a considerable period without cleaning. These requirements are obtained in the "Pyroptic" window on most ingenious lines.

The tinted glass is in the form of a panel made up of a number of narrow strips fixed horizontally one above the other, with the joining edges bevelled. This latter device prevents any white light passing between adjacent strips to




*Furnace inspection windows.*

the eye. Included also are two ¼-in. thick plates of clear fireproof glass on the furnace side, and one similar plate on the outer side, which absorb some of the radiant heat on the "accumulator" principle before it reaches the tinted glass. Consequently, the latter is kept at a more or less uniform temperature without fear of cracking, due, for example, to sudden changes of temperature in the furnace chamber, or by swinging open the windows. Further, the glass is free to expand and contract, so that no internal strains are caused.

It is claimed the windows can be exposed for long periods to a temperature even as high as 2,800° F. without injury. In one design the composite glass window is hinged on to an adapter plate so as to allow of easy removal from the frame for cleaning. Another and more advanced pattern of window has a heat-resisting metal shutter, which protects the glass from the heat when the window is not being used. The shutter is attached by two chains to a small overhead shaft with a short lever, which is pulled down by hand when an observation has to be made so as to uncover the tinted glass.

There seems to be an opinion that observation windows are a special sort of luxury, whereas they are just as essential for the best results as pyrometers and draught gauges, which applies to many other industries such as town's gas, glass, and ceramics, for example, as well as steam boiler plant.

## A New Range of Stop Watches.

DURING recent years many new ideas of practical utility have been introduced in British watchmaking, and these have found so much favour that the old type of watch is gradually being displaced. Much development in this respect has been made in the production of stop-watches of a type which are indispensable in the laboratory, as well as those of special usefulness in the workshop. It is of interest to note that A. Arnold and Co., London, have recently marketed a range of these stop-watches that adequately meet the requirements of the laboratory and general engineering.

The type recommended for use in general engineering functions both as an ordinary time-piece, and also as a stop-watch, giving accurate readings to within a fifth of a second. It is a 30-hour watch, fitted with lever movement, and is guaranteed for 12 months. These watches are available at very reasonable prices; for instance, one type costs 15s., and it is claimed to be ideal for the engineer.

# Some Recent Inventions.

*The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.*

## Apparatus for Pickling Metals

THERE are a number of types of pickling apparatus for dealing with metal articles in which the articles supported by a carrier are moved up and down in a pickling tank. In a recent development, however, an article carrier supported on a frame which is attached to the tank, is raised and lowered with the frame by means of suspending rods connected to the frame and to the cranks of rotating crankshafts. This improvement is claimed to provide a simplified and compact form of apparatus for imparting a vertical motion to the frame. The apparatus is designed

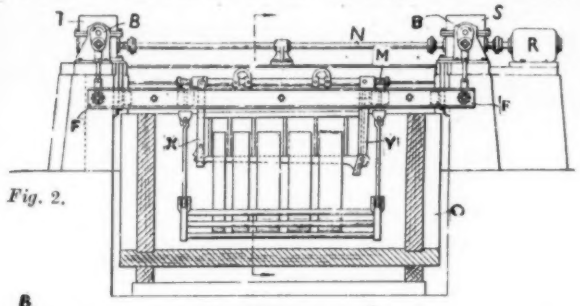


*Fig. 2.*

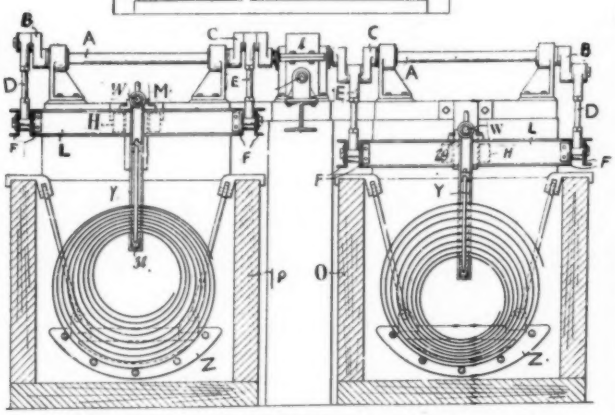


*Fig. 3.—Side and sectional elevation of pickling plant.*

primarily for the pickling of coiled metal strips and wire, but may readily be converted into a pickling apparatus for metal sheets, forgings, bars, and the like with very little trouble, thus serving a dual purpose.

The accompanying illustrations show the improved apparatus, Figs. 1 and 2 being a plan and side elevation, respectively, while Fig. 3 shows a sectional elevation. It will be noted that the shafts A have cranks B and C connected by rods D and E to rectangular frames, one frame overhanging tank, the gearing being arranged so that one frame is raised as the other is lowered.

Each frame consists of longitudinal channel irons F pivotally connected to the rods D, E, and transverse channel irons G near the ends of the members F, the channel irons G having plates H which move in vertical guides K. Transverse beams L connecting the members F are provided with saddle members M to support the article-carrier. In the form shown, an article carrier supported by the frame, the frame being raised and lowered by means of suspending rods connected to the frame and to the cranks of rotating crankshafts. A shaft N mounted above and between two pickling tanks O, P is driven by a motor R and transmits motion through gears located in gearboxes S, T and cranks V to shafts for pickling coils of metal strip or wire, the carrier comprises a bar W, the ends of which rest in the members M, with depending members X, Y, the member X being U-shaped and pivoted to the bar W. A horizontal rod is pivoted to the lower end of the member Y, the other end of the rod normally resting in the U of member X. This rod has holes to receive spacing fingers which are retained in position by a detachable keeper, and is secured in any convenient manner to the members X, Y. Eyes or loops for engagement with a lifting crane are provided on the bar W. A cradle, comprising longitudinal spaced bars, disposed in the arc of a circle is suspended in the tank by rods attached to brackets, so that on the downward stroke of the frame and carrier the coils are compressed against the cradle and the weight taken off the carrier. If the apparatus is to be used for pickling sheets, etc., the cradle Z is removed and any known form of rack or basket may be substituted for the carrier described above.

389,381. THE PHOSPHOR BRONZE CO., LTD., Sumner Street, London, S.E. 1. March 16, 1933.

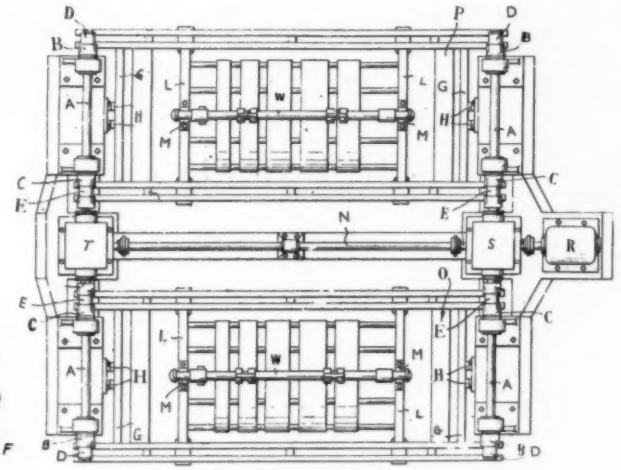


*Fig. 1.—Plan of improved pickling apparatus.*

## Treating Iron and its Alloys

IN a process for treating iron, steel, or their alloys for use in the construction of apparatus exhibiting high resistance to the action of hydrogen or gases containing hydrogen at high temperatures and pressures, the iron, etc., is annealed or shaped at a temperature above 650° C. after treatment with hydrogen or gas containing hydrogen at a temperature below the annealing temperature and under an elevated pressure. The annealing may be effected in a saline bath or in an inert atmosphere in a furnace. In an example, tubes of an alloy steel containing 0·15% of carbon, 0·27% of silicon, 0·75% of manganese, 0·32% of molybdenum, and 0·45% of chromium were treated with pure hydrogen in an autoclave at 450° C., and under a pressure of 150 atmospheres for 32 hours, and were then annealed in a barium-chloride bath at 1,050° C.

389,887. VEREINIGTE STAHL-WERKE AKT-GES, Dusseldorf, Germany.

## Reducing Iron Content in Aluminium

A PROCESS for reducing the iron content of aluminium or aluminium alloys comprises the addition of magnesium to the molten metal or alloy, and the separation of the melt into portions in the lower of which the iron has become concentrated. The melt is preferably covered with a flux, and is allowed to stand for at least 5 minutes before separation, preferably at a temperature just above that at which the least fusible constituent of the melt, other than the iron, will solidify. The amount of magnesium added may be 5-60%. The magnesium-rich product may be diluted with aluminium to form an aluminium-magnesium alloy containing, say, 5 or 10% of magnesium, and the iron-rich product may be used for refining steel.

389,054. ALUMINIUM, LTD., Toronto, Canada (Assignees of W. D. KEITH, California, U.S.A.).

## Cold Rolling Mill

MILLS for cold rolling plates suffer from the disadvantage that the feeding in of the work between the rolls is tedious and can easily take place inaccurately, since the preliminary adjustment of the plates presents difficulties. At the commencement of the operation it has previously been necessary to force the front end of the work through the opened, clamped device acting as a brake in the rolling out, and then to carry this forward by hand gradually in the direction of the rolls on a feed-table, properly adjusting it during the process, particularly just as the work is about to be seized by the rolls. Correction of inaccurately introduced work pieces, or those shifting in consequence of unequal thickness

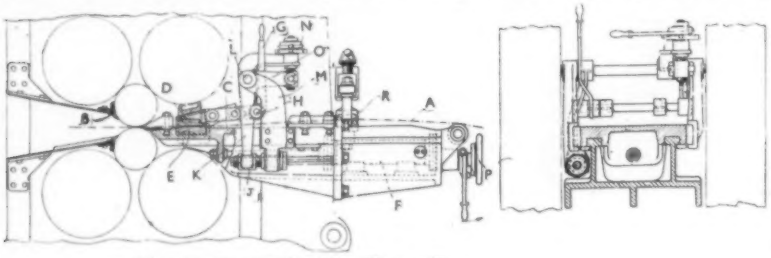



*Fig. 1.—Improved cold rolling mill.*

of material, is not possible during the working process, and in consequence inconveniences frequently arise.

A recent development, which provides a feeding-in device for the plates avoids these disadvantages. This feeding-in device comprises a sliding table, movable to and from the rolls, and having an adjustable clamping device for the plate arranged at the front end, the plate after being placed on the table, adjusted and clamped, being positively pushed by a power-drive between the rolls. The clamping device may consist of a wedge piece driven by hand or by power into a wedge-shaped bridge recess. The driving rod for this is preferably formed so that independently of the movement by the driving rod it can be shifted forward or backward by an adjustment, which is also possible during working uniformly over its whole width corresponding to the thickness of the work piece or on one side in the case of unequal thickness of material.

The arrangement is shown in Fig. 1, in which the plate A is pushed into the bite of the rolls B by a slide table C carrying friction blocks D, E, between which the plate is clamped. The table C is moved up by a hydraulic cylinder F.

The plate being located between the opened blocks D, E, with the help of side guides. The block D is closed to clamp the plate by the hand-lever G acting through toggle links and the pivot shaft H. If the plate is thinner at one side than at the other, one end of the pivot shaft H is moved by adjusting the nut J to move the lever K about its pivot L in the side frame K fixed on the slide. The other end of shaft H can also be adjusted by hand-wheel N of the bellcrank lever O in which the other end of the pivot shaft H is mounted. Further adjustment is provided by hand-wheel P, which moves the complete lever system in or out as a whole. A screw-down clamper R is also provided. Both clampers act as a brake on the plate or band.

389,306. WALZMASCHINENFABRIK AUGUST SCHMITZ, G.m.B.H., Dusseldorf, Germany. March 16, 1933.

## Heat-treating Aluminium Alloys

AGE-HARDENABLE aluminium-alloy castings are hardened by removing the castings from the mould while still at a temperature exceeding 350° C. and quenching in water. The castings may be transferred from the mould to an oven having a temperature of 420-520° C., retained there for a short time, and then quenched in water at or near boiling point. The castings may be left in the water for a considerable time—*e.g.*, about an hour. An aluminium-alloy containing 2% of copper, 1% of nickel, 1·3% of iron, 1·2% of silicon, 1·6% of magnesium, and 0·1% of titanium, and an aluminium alloy containing 7% of copper, 0·5% of nickel, 1·0% of iron, 0·6% of silicon, and 0·5% magnesium are referred to.

390,244. H. C. HALL, Littleover, Derbyshire, and C. R. M. HUTCHINSON, Walton-on-Thames.

## Draw Benches for Tubes

IN order that tube can be drawn in a continuous operation to any desired length without the necessity of a draw-bed of excessive length a bench has been devised in which two draw-carriages are utilised. These move intermittently together and then apart, in such a way that the drawing operation is not interrupted. During the major part of the operation one carriage engages the material which is being drawn, and performs the drawing operation, while the other carriage travels idly in the return motion. The idly running carriage however re-engages the material at a certain interval before the material is released from the other carriage. Although the drawing operation is uninterrupted the draw bench need only be of a comparatively short length, occupying a relatively small space.

The drawing is effected by a chain travelling continuously in the same direction, and through the intermediary of the two carriages D and F, Fig. 1. At any time one of these carriages engages the tube G and draws it because of the teeth H of the drop catch J pivoted on the carriage engages the chain. At the same time the other carriage moves in the opposite direction as the drop catch J of this carriage is raised and the jaws have released the material. The idle carriage is returned by the engaged carriage through a cable K secured to the carriage F, and passing over a fixed roller L and a roller M on the carriage D. A weight N on the cable rests on an abutment.

The operation is such that both carriages are in engagement with the chain for a short time, the weight N being lifted and then falling when the idle carriage is disengaged to move it rapidly in the return direction until the weight

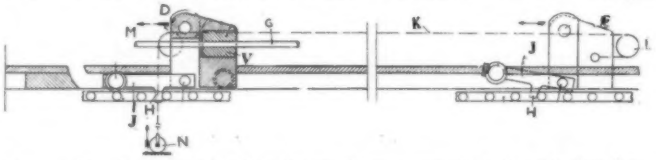



*Fig. 2.—Draw benches for continuous operation in tube drawing.*

contacts the base of the abutment, when both carriages moves with the same speed. The engagement of the drop catch J also rocks the jaws V to grip the work G.

386,154. KARL SCHWADE, Siegburg-Wolsdorf, and PAUL GEDIEN, Sieburg, both of Germany. January 12, 1933.

## Pickling Metals

ALLOYS containing chromium and resistant to corrosion or heat are pickled in a moderately dilute solution of hydrochloric or sulphuric acid containing copper, preferably added as copper sulphate. Various classes of iron-chromium, iron-nickel-chromium, and chromium-nickel alloys are referred to. Copper is deposited on the scale, and the scale and copper may then be washed away by jets of water, or the article after pickling may first be immersed in a solution which dissolves copper without acting on the alloy—*e.g.*, a solution of nitric acid or a solution containing an acid and bichromate, and then washed with a water jet. The alloys may be given a preliminary treatment with caustic soda, or a subsequent treatment with an oxidising acid. Inhibitors may be added to the pickling bath.

385,429. H. WIGGIN AND CO. LTD., and J. STOCKDALE, Birmingham.

# Some Problems of Furnace-Heating Practice.

SOME indication of the trend of development in regard to fuel practice in practically every branch is contained in the current issue ot the *Fuel Economy Review*, which deals with research work designed with a view to the more efficient and more economical use of fuel. In the various phases of the field under review Sir Robert A. Hadfield and Mr. R. J. Sarjant deal with the problems of furnace heating in the light of the latest trends of development, and of the scope for improvement of the existing practice. The authors see imported oil remaining a serious competitor to the various coal derivatives for some time, especially in areas where coke oven and producer gas and electricity are not available, and for such operations as light forging, firing kilns, and melting furnaces. But no one fuel can continue to have a monopoly. and with a continuance of developments greater use will be made of coal.

## Coal Firing.

Coal firing, as the authors state, has been the mainstay ot the bulk of our industries for generations, but now in the densely populated industrial districts the smoke problem has become acute, and technical development is being directed towards means of burning raw coal without the emission of smoke. Because the furnace plant is only part of an industrial unit, and necessarily subordinate to the needs of the job, progress must necessarily be slow, and it would be an economic impossibility, if it were always technically possible, to convert the whole of our coal-fired furnaces to modified constructions. The development of the producer-gas unit has resulted in the successful establishment of the modern mechanical producer for all but small, isolated plants. The result has been a considerable economy in the cost of generating producer gas owing to intensification of the rate of gasification from a given area of fuel bed, and mechanical cleaning of the fuel bed. However, the conditions of shop operation in many industries have introduced new requirements which militate against the use of plant requiring continuous operation or suffering otherwise heavy standby losses.

## Oil Fuel.

Because this country depends largely upon coal as the main source of heat it is important that research development should continue to be directed to the continuance of the utilisation of this source of heat. In this respect it should be borne in mind that essentially the only competition from a national standpoint really lies between imported oil and coal or the derivatives of coal. In this sense coke-oven or town's gas coke, producer gas, and even electricity, being at present mostly derived from coal in this country, must be regarded as desirable sources of energy from the national economic standpoint. Oil fuel has certain advantages in specific directions, in its high-calorific value, flame intensity, and ease of control, which characteristics may be combined in the statement that the heat is readily applied to the point at which it is desired to be used. These facts support the view that its competitive force should continue to be exercised in those districts where alternative convenient fuels are not so readily obtainable. A further feature of this case is that because oil is so widely used in all parts of the globe the technique of oil burning is of a high standard. No longer may the objection to its use be sustained that uniformity of temperature is not practicable, that good combustion conditions are not readily attainable, and that frequent shutdowns arise in cold weather by reason of choked supply lines. So long as abundant supplies of cheap fuel oil are obtainable at our ports will the competition be real.

## Pulverised and Solid Fuel.

The use of pulverised fuel, the authors assert, has not proved the panacea for all the difficulties ot British heating practice. Remarkable strides have been made in its use in America, but British coals differ in many respects from the American coals. They are harder and the milling costs are higher. British industrial units are frequently highly specialised and the heating problems carry more local conditions. For example, an instance of a steelworks is quoted in which the problem of the application of pulverised fuel has frequently been investigated in conjunction with the constructors of powdered coal plants, but in every case the special conditions necessarily imposed could not be met economically by powdered coal plants. These conditions arose from the nature of the products, a high standard of temperature uniformity over continued periods in large furnaces being demanded when the rate of heat input must be only a small fraction of the normal heating-up load.

In regard to solid fuel, it is stated that where long-flame coals are fired by a highly skilled class of operator, this kind of fuel can be applied in many types of heating operation, at an inclusive cost of less than 1d. per therm of heat applied to the furnace.

## Producer Gas.

A strongly competitive form of gaseous fuel is producer gas, which is capable of giving all the advantages of ease of control, satisfactory combustion and uniformity of heating at a price of between 1·1d. and 1·5d. per therm in suitably applied units. In small, isolated units the price may increase to as much as 2d. per therm ot available heat.

## Town's Gas.

The industrial use of town's gas for furnace heating continues to expand, especially in those districts in which there are engineering trades utilising small parts. The question ot the proximity ot coke ovens introduces a special condition, which gives this fuel an advantage economically, where costs of distribution are not ot a relatively high order. The technique of utilisation of these fuels has made considerable progress in this country during the last decade, as it has in Germany as the result of the application of a grid scheme of distribution of surplus coke-oven gas. The point has been reached at which such fuels may be applied satisfactorily as regards technique to almost any type of heating operation. In this regard special interest attaches to a recent development by the Sheffield Gas Company of a new type of furnace employing a controlled non-oxidising atmosphere. In this furnace the products of combustion are cooled in a separate air-cooled condenser for the separation of moisture, which, next to oxygen, is the most active agent of oxidation. The de-watered products are then led back into a muffle-heating chamber by means of an injector operating on a small quantity of raw gas. Combustion is designed to take place with the absence of excess air, and the material heated by this process is singularly free from heavy scale.

## Modern Trends in Furnace Mechanisation.

In dealing with modern trends of development the authors refer briefly to the question of mechanisation of furnaces, improvements in charging and discharging machines, of conveyers, and the rotary hearth and retort. With the development of mass production methods such furnaces become an essential feature of any heating process. This has been the case, for example, in the annealing of high-grade steel sheets, where the application of the "walking beam" furnace has revolutionised the practice, in the application of the electric tunnel kiln to the firing of enamelled ceramic ware, in the suspended conveyer type of furnace applied to the enamelling of hardware, and in many types of electric furnaces, for instance, those employing the contraflow principle of moving the charge on conveyers, the ingoing charge absorbing heat from the outgoing, and in which a high thermal efficiency is essential to compensate for the higher cost of the heat used.

Progress in this branch of engineering is largely bound up in the application of materials capable of combining the necessary refractory, structural, and workable properties to build moving parts which can operate at the temperatures ruling. The advances which have been made in the production of heat-resisting metals in recent years have contributed to the progress made.

# Some Recent Contracts.

The Pearson and Knowles Engineering Co., Ltd., Warrington, have been successful in obtaining the order from Stewarts and Lloyds, Ltd., for the Corby Basic Bessemer Steelworks plant. This plant is the first modern installation for the revival of the process in this country, where it was originally invented. It will be used for making the steel required for the new rolling mills and tube works now being built at Corby, Northamptonshire.

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The Tees-side Bridge and Engineering Co., of Middlesbrough a subsidiary concern of Messrs. Dorman, Long and Co., have secured a contract from Messrs. George Longden and Sons, Sheffield, for the supply and erection of a new shed ordered by the L.N.E.R. Co. at Parkeston Quay, Harwich. About 1,140 tons of copper bearing steel will be used.

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The construction of a new gas-making plant at a cost of between £35,000 and £38,000 has been decided upon by the East Hull Gas Co. The contract is for a vertical retort installation capable of producing nearly two million cubic feet of gas daily, and has been undertaken by Messrs. West's Gas Improvement Co., Ltd., Manchester. The retorts are to be of the Glover West continuous type. In this system of carbonisation no smoke or steam is discharged into the atmosphere, as each retort is a closed unit.

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Hull trawling owners are spending about £400,000 on a shipbuilding programme which started last spring and will take a year to complete. This programme represents an addition of about 20 ships to the fishing fleet. The vessels and their equipment represent a big advance and a speedier type of boat is being built. A repeat order for a deep-sea fishing trawler has been obtained by Messrs. Cochran and Sons, Ltd., Selby.

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We understand that Dorman Long and Co., Ltd. will use a new structural steel, known as "Chromador" steel, which has superior physical properties to ordinary mild steel, in several recent contracts. These will include the Storstrom Bridge, in Denmark; the Staff Annexe at the Regent Palace Hotel; and the Hong-Kong and Shanghai Bank, at Shanghai

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The Tees District Development Board have issued a Tees-side Industrial New Bulletin which gives brief information on outstanding developments in that area. This and succeeding issues will serve a useful purpose.

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We understand that the steel firms of Sheffield have been promised orders by Imperial Chemical Industries for plant required for the extraction of petrol from coal. The orders are stated to be of about £250,000 in value.

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An order has been placed with Swan, Hunter and Wigham Richardson, Ltd., of Wallsend-on-Tyne, for a steamship of 2,000 tons, by a Polish shipping company. It will ply between Gdynia and British ports, and will be specially fitted for the transport of perishable goods, which constitute the larger part of Polish exports to England.

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Grovesend Steel Co., Gorseinon, is sharing in a £700,000 contract made by the Government of the Argentine Republic with a British group of iron and galvanised steel works for galvanised iron fencing to deal with locusts in that country. A dozen other firms participate in the order, but acceptance of tenders is subject to the approval of the Argentine Senate.

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The Tyne-Tees Steam Shipping Co., Ltd., of Newcastle, through Sir Arthur M. Sutherland, the chairman, have placed an order with Messrs. R. and W. Hawthorn, Leslie and Co., of Hebburn-on-Tyne, for a motor coasting vessel. The vessel, which will trade between London, Selby, King's Lynn, Boston, and Ipswich, will have a light draught and will carry 330 tons.

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Swan, Hunter and Wigham Richardson, Ltd., Wallsend, have on hand a cruiser and two destroyers, three train-ferry steamers, a big motor-ship for the Dominion and Commonwealth Line, and a collier.

The Bolsover Colliery Co., Ltd., Bolsover, near Chesterfield, have placed an order with Simon-Carves, Ltd., Cheadle Heath, for a coal washery. The plant, which is to be installed at the Bolsover Pit, will have a capacity of 175 tons an hour. This is the fifth order for coal washeries received by Simon-Carves from the Bolsover Co.

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Messrs. R. and W. Hawthorn Leslie and Co., Hebburn-on-Tyne, have received an order from the Admiralty for the building of a first-class sloop for service in India.

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## Grid Scheme Complete

The last of the 26,265 pylons completed near Fordingbridge, on the outskirts of the New Forest, conclude the greatest scheme of its kind in the world. By the grid scheme the Central Electricity Board have taken electricity to the doorsteps of nearly every village and hamlet in England, Wales, and Southern Scotland. The scheme has meant employment, directly or indirectly, to thousands of workers, and it has provided a stimulus to many British industries when they were most in need of outlets for their products. Thus, the iron and steel and coal industries have benefited, as also have the aluminium and pottery industries.

Some indication of the quantity of material involved in the construction of the grids will be realised when it is stated that 170,000 tons of steel were used, 12,000 tons of aluminium, 500,000 tons of cement, 200,000 insulators. Altogether there are 4,000 miles of transmission lines, 2,894 miles representing lines operating at 132,000 volts, the remainder operating at 33,000 and 66,000 volts. In addition, it has necessitated the building and equipment of powerful generating stations, some of which are not yet completed.

Towards the end of 1934 the whole system will be working, carrying a wholesale supply of electricity to practically every corner of Great Britain. It is estimated that the grids will be loaded to the extent of 70% in 1935, and fully loaded in 1940 when the output of electricity will be 25,000,000,000 units.

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## The Wilkinson Memorial Award

For the ninth year the examination for the award of the John Wilkinson Memorial medal was held at the close of the session for the Junior section of the Lancashire Branch, Institute of British Foundrymen. The examiners have now issued the result showing that the winner of the medal and first prize is Mr. B. Haigh, who was a winner also on a former occasion. The second position and book prize were awarded to Mr. C. Sutcliffe, patternmaker with Messrs. Entwistle and Gass, Ltd., and the following competitors have been highly commended: Mr. O. Bateson, patternmaker, Jackson and Brothers, Ltd.; Messrs. J. Hough and W. Kershaw, both apprentice moulders at Messrs. C. Walmersley, Ltd. The award of the prize for the short paper competition which occupied the final meeting of the session has been made to Mr. O. Bateson for his paper on "The Finishing of Patterns."

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## PERSONAL

Dr. W. R. D. Jones has been appointed to the Chair of Metallurgy of the University of South Wales and Monmouthshire, Cardiff, on the retirement of Professor A. A. Read.

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Mr. T. D. Morgan, M.I.Mech.E., has been appointed agent in South Wales and the West of England for Wild-Barfield Electric Furnaces, Ltd., and G. W. B. Electric Furnaces, Ltd. Mr. Morgan's address is Glaisdale, Porthcawl, Glam.

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Mr. G. W. Barr, of Barrow-in-Furness, has been appointed deputy managing director of the Fairfield Shipbuilding and Engineering Co., Ltd., under Sir Alexander M. Kennedy, the chairman and managing director of the company.

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Mr. H. C. Loving, chief engineer of the English Steel Corporation, has been appointed chief engineer of the Tata Iron and Steel Co., Ltd., India.

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Mr. F. G. Child has been appointed general manager, Messrs. Charles J. W. Barwell, the Hockley Copper and Brass Tube Works, Birmingham.

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Mr. J. E. Newson has taken up the appointment of chief metallurgist to the Manganese Bronze and Brass Co., Ltd., London.

# Business Notes and News

## New Sheet Lead Works

The old Bessemer steel works in Sheffield have been converted and equipped for the production of sheet lead. This new Sheffield industry has been commenced by H. Polan and Co., Ltd., who have been established as lead pipe manufacturers in Sheffield since 1923. The new plant has just been put into operation and considerable expense has been involved in making the necessary structural alterations and the installation of the necessary furnace, mill, and subsidiary machinery.

A gas-fired furnace of eight tons capacity has been installed. This is fed with Empire lead from the Broken Hill mines in Australia, and the molten lead run into a casting plate, heated by gas, measuring 8 ft. by 5 ft. 6 in. When this is cooled sufficiently—usually about 15 minutes after casting—the plate is lifted and placed on the rolling-mill bed. Here the lead is trimmed and cut with an electrically operated guillotine, and is eventually rolled to requisite dimensions by automatically controlled rollers.

The mill is 80 ft. long, and provides the facilities for rolling a length of sheet greater than that usually required and a normal width of 8 ft. It is built on the most modern lines and is equipped with electrical control. In its present form the plant has a capacity of 16 tons of sheet lead per day, and since it is the first of its kind to be erected in the Sheffield district it should be capable of operating on a regular basis.

## Expansion in the Use of Tin

In spite of the depressed conditions of most manufacturing industries, states a report issued by the United States Bureau of Mines, there has been a constant expansion in the number of aeroplanes and mechanical refrigerators in use. The manufacture and maintenance of these machines are becoming an important outlet for tin. The legalisation of beer in the United States probably will increase the demand for tin, because of the extensive use in breweries and beer dispensing equipment. Pipes, valves, and other fixtures of pure tin are used in handling the beverage, while much tin will be consumed in the refrigerating equipment that will be needed by the retail beer trade.

Another development in tin consumption mentioned in the report is the adoption by leading automobile manufacturers of tin-plated pistons to combat cylinder friction. Much curtailment of tin consumption during the period since 1929 has been for needs that will ultimately be supplied. Consequently, tin producers can look forward with some degree of optimism because much business, particularly in the building trades, is not lost, but postponed.

## Bartering Coal for Iron Ore

Messrs. Guéret, Llewellyn and Merrett, Ltd., the coal exporting organisation at Cardiff, have made a further transaction under which 25,000 tons of Newfoundland iron ore will be exchanged for Welsh locomotive coal of an equivalent value. British steamers will be employed. This firm are now completing a recent barter transaction by which Welsh locomotive coal will be exchanged for 48,000 tons of Newfoundland props.

The iron ore from Newfoundland will be taken by the British (Guest, Keen, Baldwins) Iron and Steel Co., Ltd., and will be imported at Cardiff and Port Talbot.

## Institute of British Foundrymen
### (Lancashire Branch)

This session the Lancashire branch are making a departure from their experiment of last year, when all seven of the papers were read by their own members, for the entire syllabus is being taken by members of other branches of the Institute. On three occasions the illustrations are being supplemented by means of cinema films, thus bringing the foundry to the members, instead of the usual reverse proceeding. Another innovation proposed is to hold all their meetings on the first Saturday afternoon of each month at the Engineers' Club in place of the venue of so many of the past session in the College of Technology. The syllabus is now published in the handbook of the Lancashire branch. The session will commence on October 7, when Mr. A. Phillips will deliver his Presidential address. This will be followed by a lecture on "The Manufacture of Mammoth Cunard Castings," by Mr. F. Swift, of Darlington. Films will be used to illustrate the lecture.

## Petrol from Coal

The Directors of the Imperial Chemical Industries, Ltd., have authorised a scheme for the erection of a large commercial plant which is to be located at the company's works at Billingham-on-Tees. An initial output of 100,000 tons a year of first grade petrol is aimed at by processing 400 tons of coal a day, and using altogether about 1,000 tons of coal a day.

The operation of the plant will materially improve conditions on Tees-side, as it will give permanent direct employment to 2,500 miners and other workers, as well as much indirect employment. The construction of the plant itself, which is estimated to take about one and a half years, will call for much activity in the iron and steel and heavy industries, and it is claimed seven thousand men will find direct employment during this one and a half years, and it is expected that there will be indirect employment for a further five thousand men, as a result of this scheme. The necessary new capital of about two and a half million sterling will be furnished by Imperial Chemical Industries, Ltd., from their own resources.

## The "Devereux" Prize

The North Western branch committee of the Institution of Welding Engineers have just announced their acceptance of an interesting prize offered by the chairman of the branch, Mr. H. M. Devereux, which has been promoted with the object of enhancing the value of the discussion on papers read before them in the current and future sessions. The prize to the value of three guineas in form of medal, books or instruments,will be balloted for by the members attending the meetings, and the award will go to the member, associate or graduate, who in their opinion has given the most valuable and interesting contributions to the discussions on any or all of the papers read during the session. These contributions are not to exceed ten minutes in delivery, and are not to be read from a written communication, although reference to notes is of course permissible. Although advance copies of the papers are not always available, those members, etc., who cannot attend the meeting, may send their contributions to the discussion dealing with the subject of the paper to the Branch Secretary, and the communications shall be read by a member of the committee, and thus rank as a verbal discussion. The North Western branch of the Institution now has well over 100 members, and an interesting syllabus of papers has been arranged, and will be issued shortly. This includes several meetings in towns near Manchester, at which cinema films of welding processes will be shown.

## New Master Cutler

Mr. Charles John Walsh, one of the general managers of the United Steel Companies, Ltd., was elected Master Cutler in succession to Lieut-Col. A. N. Lee.

At the meeting of the Cutlers' Company of Hallamshire, held in Sheffield recently, when the election took place, it was announced Mr. Walter Runciman, President of the Board of Trade, is to be chief guest at the next Cutlers' Feast on Oct. 18.

Other appointments were: Mr. A. Williamson, Senior Warden; Sir Samuel Roberts, M.P., Junior Warden; Col. F. A. Neill, Lieut-Col. W. Tozer, Mr. E. Dixon, Mr. J. G. Ellict, Col. E. W. Wilkinson, and Mr. A. J. Grant, Searchers; Lieut.-Col. A. N. Lee, Messrs. Joseph Ward, P. B. Brown, A. K. Wilson, T. G. Sorby, P. W. Lee, D. Flather, T. R. Ellin, W. W. Wood, R. W. Matthews, W. Clark, Lt.-Col. H. K. Stephenson, Sir William Ellis, Sir Arthur Balfour, Bt.,Messrs. W. F. Osborn, W. R. S. Stephenson, A. S. Ward, A. E. Bassett, S. E. Osborn, W. B. Jones, Col. D. S. Branson, and Messrs. J. G. Graves, G. W. Vickers, and R. A. Balfour, Assistants.

The new Master Cutlers' installation will take place at the Court House, Sheffield, on October 3.

## Big New Soviet Steel Combine

The designs have been prepared for the building of a big new steel combine at Bakalsk in the Cheliabinsk region. The combine is designed for a capacity of 1.8 million tons of steel castings a year, nearly three times the capacity of the Midland Steel Works of the United States, which is the biggest plant in the world producing high grade steel. The first unit of the Bakalsk combine is to consist of two blast-furnaces, one small blooming mill, and one big press. Building is to be commenced next year. The first unit is to be completed by 1937.

# MARKET PRICES

## ALUMINIUM.

| | | | |
|---|---|---|---|
| 98/99% Purity | £100 | 0 | 0 |

## ANTIMONY.

| | | | |
|---|---|---|---|
| English | £37 10 0 to £40 | 0 | 0 |
| Chinese | 26 | 10 | 0 |
| Crude | — | | |

## BRASS.

| | | |
|---|---|---|
| Solid Drawn Tubes | lb. | 9½d. |
| Brazed Tubes | „ | 11¼d. |
| Rods Drawn | „ | 8¾d. |
| Wire | „ | 7¾d. |
| *Extruded Brass Bars | „ | 4¼d. |

## COPPER.

| | | | |
|---|---|---|---|
| Standard Cash | £35 | 15 | 0 |
| Electrolytic | 39 | 0 | 0 |
| Best Selected | 37 | 15 | 0 |
| Tough | 37 | 5 | 0 |
| Sheets | 66 | 0 | 0 |
| Wire Bars | 39 | 5 | 0 |
| Ingot Bars | 39 | 5 | 0 |
| Solid Drawn Tubes | lb. | 10½d. | |
| Brazed Tubes | „ | 10½d. | |

## FERRO ALLOYS.

| | | | | |
|---|---|---|---|---|
| ‡Tungsten Metal Powder | lb. | 0 | 2 | 0 |
| ‡Ferro Tungsten | „ | 0 | 1 | 9 |
| Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up. | | | | |
| NOMINAL 2–4% Carbon, scale 12/– per unit | ton | 29 | 0 | 0 |
| NOMINAL 4–6% Carbon, scale 7/– per unit | „ | 21 | 5 | 0 |
| NOMINAL 6–8% Carbon, scale 7/– per unit | „ | 19 | 15 | 0 |
| NOMINAL 8–10% Carbon, scale 7/– per unit | „ | 18 | 17 | 6 |
| §Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit | „ | 30 | 15 | 0 |
| Guar. max. 1% Carbon, scale 12/6 per unit | „ | 33 | 10 | 0 |
| §Guar. max. 0·7% Carbon, scale 15/– per unit | „ | 37 | 2 | 6 |
| ‡Manganese Metal 96–98% Mn. | lb. | 0 | 1 | 4 |
| ‡Metallic Chromium | „ | 0 | 2 | 8 |
| § Ferro-Vanadium 25–50% | „ | 0 | 12 | 8 |
| § Spiegel, 18–20% | ton | 7 | 10 | 0 |
| Ferro Silicon— | | | | |
| Basis 10%, scale 3/– per unit | ton | 5 | 2 | 6 |
| 20/30% basis 25%, scale 3/6 per unit | „ | 7 | 17 | 6 |
| 45/50% basis 45%, scale 5/– per unit | „ | 11 | 17 | 6 |
| 70/80% basis 75%, scale 7/– per unit | „ | 18 | 10 | 0 |
| 90/95% basis 90%, scale 10/– per unit | „ | 30 | 0 | 0 |
| § Silico Manganese 65/75% Mn., basis 65% Mn. | „ | 13 | 15 | 0 |
| § Ferro-Carbon Titanium, 15/18% Ti | lb. | 0 | 0 | 6 |
| Ferro Phosphorus, 20–25% | ton | 15 | 18 | 0 |
| § Ferro-Molybdenum, Molyte | lb. | 0 | 5 | 6 |
| § Calcium Molybdate | „ | 0 | 5 | 4 |

## FUELS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Foundry Coke— | | | | | | |
| S. Wales | £1 | 0 | 0 to | 1 | 2 | 6 |
| Scotland | — | | | 1 | 8 | 0 |
| Durham | 1 | 1 | 0 to | 1 | 5 | 0 |
| Furnace Coke— | | | | | | |
| Scotland | — | | | 1 | 5 | 6 |
| S. Wales | — | | | 0 | 15 | 6 |
| Durham | 0 | 13 | 0 to | 0 | 13 | 6 |

## GUN METAL.

| | | | |
|---|---|---|---|
| *Admiralty Gunmetal Ingots (88 : 10 : 2) | £55 | 0 | 0 |
| *Commercial Ingots | 45 | 0 | 0 |
| *Gunmetal Bars, Tank brand, 1 in. dia. and upwards | lb. | 0 | 0 9 |
| *Cored Bars | „ | 0 | 0 11 |

## LEAD.

| | | | |
|---|---|---|---|
| Soft Foreign | £11 | 15 | 0 |
| English | 13 | 5 | 0 |

## MANUFACTURED IRON.

| | | | |
|---|---|---|---|
| Scotland— | | | |
| Crown Bars, Best | £10 | 5 | 0 |
| N.E. Coast— | | | |
| Rivets | 10 | 15 | 0 |
| Best Bars | 10 | 5 | 0 |
| Common Bars | 9 | 5 | 0 |
| Lancashire— | | | |
| Crown Bars | 9 | 0 | 0 |
| Hoops £10 10 0 to | 12 | 0 | 0 |
| Midlands— | | | |
| Crown Bars £8 0 0 to | 9 | 0 | 0 |
| Marked Bars | 12 | 0 | 0 |
| Unmarked Bars | — | | |
| Nut and Bolt Bars £6 15 0 to | 7 | 10 | 0 |
| Gas Strip | 10 | 12 | 6 |
| S. Yorks — | | | |
| Best Bars | 10 | 15 | 0 |
| Hoops £10 10 0 to | 12 | 0 | 0 |

## PHOSPHOR BRONZE.

| | | |
|---|---|---|
| *Bars, " Tank " brand, 1 in. dia. and upwards—Solid | lb. | 8d. |
| *Cored Bars | „ | 10d. |
| †Strip | „ | 10½d. |
| †Sheet to 10 W.G. | „ | 11d. |
| †Wire | „ | 1/0½ |
| †Rods | „ | 11d. |
| †Tubes | „ | 1/4 |
| †Castings | „ | 1/1½ |

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

## PIG IRON.

| | | | |
|---|---|---|---|
| Scotland— | | | |
| Hematite M/Nos. | £3 | 6 | 0 |
| Foundry No. 1 | 3 | 7 | 6 |
| „ No. 3 | 3 | 5 | 0 |
| N.E. Coast— | | | |
| Hematite No. 1 | 2 | 19 | 6 |
| Foundry No. 1 | 3 | 5 | 0 |
| „ No. 3 | 3 | 2 | 6 |
| „ No. 4 | 3 | 1 | 6 |
| Silicon Iron | 3 | 5 | 0 |
| Forge | 3 | 1 | 6 |
| Midlands— | | | |
| N. Staffs Forge No. 4 | 3 | 1 | 0 |
| „ Foundry No. 3 | 3 | 6 | 0 |
| Northants— | | | |
| Foundry No. 1 | 3 | 5 | 6 |
| Forge No. 4 | 2 | 17 | 6 |
| Foundry No. 3 | 3 | 2 | 6 |
| Derbyshire Forge | 2 | 19 | 0 |
| „ Foundry No. 1 | 3 | 6 | 0 |
| „ Foundry No. 3 | 3 | 3 | 6 |
| West Coast Hematite | 3 | 6 | 0 |
| East „ „ No. 1 | 3 | 0 | 0 |

## SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18–16 to £1 approximately.

Pig Iron Kr. 90
Billets Kr. 230-290 £12 13 4–£16 0 0
Wire Rods Kr. 265-320 £14 12 6–£17 12 6
Rolled Bars (dead soft) Kr. 185-210 £10 4 0–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton, f.o.b. Gothenburg.

## SCRAP METAL.

| | | | |
|---|---|---|---|
| Copper Clean | £29 | 0 | 0 |
| „ Brazery | 26 | 0 | 0 |
| „ Wire | — | | |
| Brass | 19 | 10 | 0 |
| Gun Metal | 27 | 0 | 0 |
| Zinc | 10 | 10 | 0 |
| Aluminium Cuttings | 72 | 0 | 0 |
| Lead | 11 | 0 | 0 |
| Heavy Steel— | | | |
| S. Wales | 2 | 8 | 0 |
| Scotland | 2 | 5 | 0 |
| Cleveland | 2 | 5 | 0 |
| Cast Iron— | | | |
| Midlands | 2 | 0 | 0 |
| S. Wales | 2 | 5 | 6 |
| Cleveland | 2 | 0 | 0 |
| Steel Turnings— | | | |
| Cleveland | 1 | 11 | 6 |
| Midlands | 1 | 5 | 6 |
| Cast Iron Borings— | | | |
| Cleveland | 1 | 2 | 0 |
| Scotland | 1 | 13 | 0 |

## SPELTER.

| | | | |
|---|---|---|---|
| G.O.B. Official | — | | |
| Hard | £14 | 12 | 6 |
| English | 17 | 12 | 6 |
| India | 16 | 10 | 0 |
| Re-melted | 16 | 12 | 6 |

## STEEL.

| | | | |
|---|---|---|---|
| Ship, Bridge, and Tank Plates Scotland | £8 | 15 | 0 |
| North-East Coast | 8 | 15 | 0 |
| Midlands | 8 | 17 | 6 |
| Boiler Plates (Land), Scotland | 9 | 0 | 0 |
| „ „ (Marine) „ | — | | |
| „ „ (Land), N.E. Coast | 10 | 0 | 0 |
| „ „ (Marine) „ | 10 | 10 | 0 |
| Angles, Scotland | 8 | 7 | 6 |
| „ North-East Coast | 8 | 7 | 6 |
| „ Midlands | 8 | 7 | 6 |
| Joists | 8 | 15 | 0 |
| Heavy Rails | 8 | 10 | 0 |
| Fishplates | 12 | 0 | 0 |
| Light Rails £8 10 0 to | 8 | 15 | 0 |
| Sheffield— | | | |
| Siemens Acid Billets | 9 | 2 | 6 |
| Hard Basic £8 2 6 and | 8 | 12 | 6 |
| Medium Basic £6 12 6 and | 7 | 2 | 6 |
| Soft Basic | 6 | 0 | 0 |
| Hoops £9 10 0 to | 9 | 15 | 0 |
| Manchester Hoops £9 0 0 to | 10 | 0 | 0 |
| Scotland, Sheets 24 B.G. | 10 | 5 | 0 |

## HIGH SPEED TOOL STEEL.

| | | |
|---|---|---|
| Finished Bars 14% Tungsten | lb. | 2/– |
| Finished Bars 18% Tungsten | „ | 2/9 |
| Extras | | |
| Round and Squares, ½ in. to ½ in. | „ | 3d. |
| Under ½ in. to 3/16 in. | „ | 1/– |
| Round and Squares 3 in. | „ | 4d. |
| Flats under 1 in. × ⅜ in. | „ | 3d. |
| „ „ ½ in. × ¼ in. | „ | 1/– |

## TIN.

| | | | |
|---|---|---|---|
| Standard Cash | £216 | 15 | 0 |
| English | 217 | 5 | 0 |
| Australian | 220 | 10 | 0 |
| Eastern | 223 | 0 | 0 |
| Tin Plates I.C. 20 × 14 box | 0 | 17 | 0 |

## ZINC.

| | | | |
|---|---|---|---|
| English Sheets | £26 | 0 | 0 |
| Rods | 30 | 10 | 0 |
| Battery Plates | — | | |
| Boiler Plates | — | | |

* McKechnie Brothers, Ltd., quoted Sept. 12. † C. Clifford & Son, Ltd., quoted Sept. 12. ‡ Murex Limited, quoted Sept. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices quoted Sept. 12, ex warehouse.